lar blocks at its angles in both plastered and unplastered walls, it was usual to have no vertical end joints between these blocks and the wall, but irregular ones, Fig. 18. This gives a picturesque character to the masonry, to be sought in all economically constructed buildings as the only means for obtaining a simple and esthetic treatment. The Renaissance first abandoned this method and constructed masonry of a very regular series of ashlar blocks. All kinds of irregular masonry, comprising Cyclopean and the kinds forming a transition to ashlar masonry, have a character of simplicity, necessity and economy; Roman and Renaissance builders applied to them, as well as to roughly wrought ashlar, the term 'rustic' (rural or boorish) as a distinction from the regular and smoothly dressed masonry of the more prominent buildings in cities. However inappropriate this term, it is not easily replaced by a better one. To soften the effect of this unpretending but picturesque masonry by subduing the joints, either by making them as thin as possible, or by giving the mortar the same color as the stone, is the error of a pedant, never found in any good architectural style. The irregularities of the masonry require a good bed of mortar, and this bed must be visible as evidence of the durability of the masonry. To subordinate the joints is to dispense with the only means of obtaining a certain variety in appearance without too great cost. Unity must be sought, not in uniformity of appearance, but in the principles controlling variety, and which must be apparent, unless the work is to appear insipid, characterless and weak, qualities unfortunately now too commonly preferred to the picturesque the natural and the strong.

4. Ashlar Masonry of Small Stones.

A mode of construction common in all Roman provinces is the die-work, a kind of incrustation on walls, composed of small pyramidal stones 3 to 4, rarely 6 to 7 in. square, set with broken joints and in a very thick coat of mortar, Fig. 19. This die-work is at intervals interrupted by courses of brick-work deeply bonded into the wall. This masonry is especially common in Gallo-Roman buildings, but long survived the fall of the Roman Empire in central France; the Clara Tower in Cologne and the imperial palace at Treves are the only known examples of its occurrence in Germany.

The Roman net-work or Opus reticulatum is allied to this die-work, and is composed of pointed pyramids of tufa 3 1-2 to 5 in. square, Fig. 20; Fig. 21 is a specimen from Pompeii. The Opus reticulatum and die-work are peculiarly decorative bonds for facing concrete masonry, but are seldom used in modern times, except for paving streets.

A kind of masonry composed of small and regular, though rud-ly wrought oblong stones with thick joints, was in common use among the Romans; it was much used in mediaeval buildings in France and Germany, and is still preferred in countries furnishing easily wrought materials, like Brohlthal tufa and the variegated sandstone of the middle and upper Rhine provinces.

b. Ashlar Masonry of Large Stones.

Ashlar masonry proper requires consideration in three ways; the mode of preparing the stones, the bond, and the means of fixing and clamping the ashlars together.

a. Mode of working.

If the blocks of stone are quarried with powder, fire, or b[y] a series of driven wedges, they are worked to blocks of prescribed dimensions with approximately rectangular surfaces, still rough and uneven, so that about an inch must be dressed off each side to obtain a true surface, the "working inch". The first dressing is done at the quarry; the stone being lai[d] on a low bench, larger projections are knocked off with the sledge a, Fig. 22. The surface is then dressed with the pick to show parallel strokes. The axe or point c is then used, t[he] the axe having a long handle and being used in both hands. The point is struck with the wooden mallet d, or with a hammer in dressing granite. When the pointing is finished, the surface should be tolerably true. The top is then laid off in rec-tangular form, and the projections of the edges beyond these lines removed by the sledge (or pitching chisel). The four edges perpendicular to the wrought surface are then wrought and tried with the square, the remaining surfaces being dressed from their edges toward their centres. The stone is then termed a pointed ashlar.

The second series of processes in cutting ashlars is the dressing of the edges with the chisel and mallet or axe, making a draft along the edges by fine parallel strokes, four drafts forming the margins of the stone. The pointed surface of the ashlar is dressed with the crandall b, producing a pointed appearance. Only faces of ashlars are usually crandalled, beds and joints being usually only pointed. In case of hard stone, as granite, syenite, etc., the bush-hammer c is used in place of the crandall, and is entirely of steel, having 16 to 40 or more pyramidal points.

The third operation in finely dressing stone is cutting with the broad chisel d, held in the left hand like the point, and struck with the mallet, producing fine lines on the surface. Drafts alone are chiselled sometimes. The further smoothing of all ashlar is done by finer chiselling; lastly, the stone is also sometimes well polished.

...rough h... ..s, pointing, drafting and crandalling, chiselling ... ...boing, are therefore the general methods of prepar... ...ars and cut stone work.

... the mode of working here explained are derived the suc... ...ive points for treatment of ashlar and cut stone, especially of their faces. It is evident that the bed and end joints must be pointed sufficiently fine to lie moderately close on each other, so as to avoid the use of too much mortar.

A simple dressed margin is the simplest mode of working ashlars to obtain external effect, and the least that can be accepted; the surface then receives the treatment suitable for cut stone, this depending on the specific peculiarities of the material employed, its texture, its conchoidal, slaty, or splintery fracture, and the corresponding difference in external appearance, so that each material has its proper mode of dressing. As the chisel used for drafted margins has a fixed breadth for both large and small stones, this modifies the effect of the ashlars, so that large blocks appear to have narrow margins and small blocks wide ones. The projection of the roughly wrought central boss varies according to dimensions of the stone, and the purpose to which it is to be applied. They are so great in the Pitti Palace at Florence, that one may find shelter from the rain beneath them. This simplest mode of dressing will always be satisfactory when economy of labor is required, as in basement walls, manufactories, engineering works, fortifications, etc.

Pointing surfaces is the second mode of treatment, pointed faces of ashlars contrasting with those roughly dressed, when a difference in mode of cutting is desired to express a different and finer quality of masonry. Especially common in the treatment of the main portion of a structure. If the base of a building be of ashlars with rough, strongly projecting bosses, the lower story may be composed of pointed ashlars.

According to the greater or less projection of the bosses of ashlars and their more or less fine pointing, several grades are possible in the appearance of the masonry. In both pointed ashlar and that with bosses, the drafted margins are necessary to clearly mark the joints of the ashlars, as well as to give the ashlar a general appearance of having at least received the minimum preparation permissible. If the drafted margin be entirely omitted, the ashlar loses its characteristic el element of form.

Crandalling the surface of ashlar is but a transition or intermediate step between pointing and chiselling, and should not be used in architectural work, beacuse not beautiful. The stone should be chiselled, if the means admit; if not, it s-

should then be left rough or fine pointed. Bush-hammering for very hard stones is the extreme limit of smoothness usually permissible, especially in engineering and fortifiaation. Finally, chiselling is usually the highest limit of preparation possible for fine-grained stones and the best cut stone; the drafted margins almost entirely disappear, the chisel marks being chipped away. Stone is very seldom rubbed, except fine-grained material of good color, taking a good polish. (Rubbed stone is much used in the U.S. for good buildings in cities, because requiring less skilled labor, less affected by strikes, etc. Just at present, Richardson pitchedfaced masonry of irregular squared ashlars is most in vogue, but rubbed masonry will doubtless soon be in favor again).

In contrast to the ashlar of the wall, in which may be used the most diverse modes of treatment for characterizing the masonry, it is natural that on moulded or ornamental cut stone, projecting bosses are to be avoided; the best cut stone mouldings, ornamental blocks, etc., are wrought from fine-grained stone as a rule, for which a more delicate treatment is suitable; if one can economise by using similar ashlar blocks, this economy entirely disappears in the best cut stone work, since these are then seldom duplicated; or one may economize on the ashlars, to be able to expend more on the ornamented blocks. It is in bad taste to form bosses on architectural details.

The Greeks and Romans set stones partly roughly wrought, and partly having projecting bosses; after the completion of the structure, these projecting stones were wrought into members and ornaments. Many ancient buildings were then never completed, like the Temple at Segeste, parts of the Coliseum at Rome and the Porta Nigra at Treves. This mode of building was in part traditionally retained in Romanesque of the 10 th to the 13 th centuries. The ashlars and most architectural features were set finished, as furnished by the masons' lodges, only special portions, like bases and capitals of columns, and many of the more elaborate decorations of cornices, being wrought after the setting of the stone. Hence, many parts of Romanesq buildings have also remained unfinished.

During the Gothic period from the 13 th to the 16 th centuries, cut stone work was always finished in the masons' sheds and was therefore set in a perfect form. Renaissance masters after the middle of the 15 th century followed the ancient method in a peculiar way; not having a thorough knowledge of classic antiquity, due to numerous modern scientific investigations, and therefore being unable to correctly explain all appearances, they accepted everything found in ancient buildings in good faith, and used it in the same way, assuming inc-

incomplete work to be finished and imitating it. In this is the explanation of many Renaissance peculiarities.

Desiring to build economically and rapidly, we employ for the substructure of a building only the most indispensable care, so as to devote all our power and artistic skill to the more important portions of the building, as also done in all ancient temples and other structures. The first thing is to place a layer of stones on a solid foundation, on which to erect the building. Gigantic blocks, with dimensions surpassing those of prehistoric monuments ascribed to giants, were laid in the temple terrace at Baalbec, blocks 68 ft. long and 14 ft. high being used; it is evident that beds were merely roughly dressed and margins were drafted, leaving the projecting boss quarry-faced, only removing its greatest projections. Romans inherited from past eras, and adopted the methods of all preceding races, introducing them into all countries under their sway, so that we find this rusticated masonry used in all Roman buildings.

During the Middle Ages, this masonry with projecting bosses was merely used in fortifications and is usually rare; smooth masonry was preferred during this period. It first reappeared in the 15 th century in Florentine palaces, and was assumed to have been invented by the Etruscans, ancestors of the Tuscans, it being made a special feature of the Tuscan Renaissance solely for this reason. An attempt was made to harmonize the most diverse modes of cutting stone with the orders of columns, so as by means of ashlar masonry to express the character of the orders in the treatment of the mass of buildings, even without the use of columns or pilasters. This was at last carried so far, that in imitation of unfinished Roman buildings, columns and pilasters were even composed of rectangular or cylindrical ashlars with bosses, an error that should never be made now.

A special form of this ashlar masonry with bosses appears in fortification at the end of the 15 th century, the spherical boss, suggested by the use of artillery; Viollet-le-Duc gives an example from the Gate of the walls of Vezelay, 1515-1547.

Renaissance architects invented diamond-panelled ashlars, in which a drafted margin surrounds a boss in form of a low pyramid. If the blocks are square, they are called nail-head. In Fig. 24 is an example of diamond-panelled ashlar masonry from a church in Naples; Fig. 25 is another example composed of alternating ashlars with diamond panels and spherical bosses, from the old Fort St. John at Florence. A variation of the motive tive of this panelled ashlar, which may be required for richer buildings, bases of monuments of polished stone, etc., consists in moulding the margins, Fig. 26, and also in trunca-

ting the pyramidal bosses. Certain blocks, like corner stones of the base of a monument, keystone of an arch, etc., should be more richly moulded, but one must then be careful to not approach too closely to the forms of wood-work.

A decorative treatment of the surface of the ashlar itself, and all over refined modes of cutting this, are objectionable, as expending means for an improper purpose; for the same cost of decorating the ashlars with all kinds of niceties in the art style of the Barocco period, we may richly supply the architecture with decorative or sculptured ornament, or we may employ nobler material. Still, it should not be forgotten in purely decorative works, such as portals, monuments, etc., that such decoration of the ashlars by ornamental patterns may be permissible in exceptional cases.

To mould the margins of the surfaces of the ashlars, leaving the bosses rough, is a contradiction; the rough bosses are esthetically justified by their bold effect and their economy; if the means suffice for moulding the ashlars, it is preferable to change the bosses into diamond panels. Such a contradiction appears like affectation.

The simplest means for causing the joints of the stones to have a bold effect consists in either making the surfaces of the ashlars project beyond the face of the wall, forming rectangular joints enclosing the surface of each block, Fig. 27, a b, c, d, or in giving the joints a triangular section, sinking this behind the face of the wall, Fig. 27 e. The actual structural joint is formed by the bed of the stone in the first case, so that the projecting surfaces of the ashlar protects the joint from penetration of rain water. To replace the edges of the projecting surface by chamfers, quarter rounds, coves or other mouldings, would greatly increase the cost of the ashlar masonry, but would also increase the richness of appearance of the joints, and is therefore to be limited to those parts of buildings, in which an increased number of expedients is desired, as in substructures, the accentuation of corners and angles, etc. The joints themselves, at the surface of the wall from which the ashlar projects, should not exceed the width of the chisel, and their width must be constant if the effect be too slight in case of large blocks, the joint can be made wider outwards with trapezoidal sections. Fig. 27

Triangular joints usually have a right-angled section when executed in the usual building materials; their effect is more marked if their surfaces make angles of 60 deg. with each other; Fig. 27 a, b, c; when this diedral angle exceeds 90 deg., they appear broad and have a weak effect. Fixed rules for the proportions of ashlar joints cannot be given, since their ef-

fect must always harmonize with the purpose for which they are employed. Taking the width of a chisel as a basis for a richly moulded joint, Fig. 27 a, d, the smaller fillets, chamfers and mouldings must have such dimensions as may be required for light and shade, and a varied alternation of proportions.

To treat all ashlar joints as purely decorative, where no structural joint is required, concealing the real joints, is one of the greatest barbarisms borrowed from Barocco architecture by modern architects. Architecture disappears with construction; one requires the other, and one who does not understand how to develop the nature of the former from the latter, can never equal mediaeval masters, nor those of the best Renaissance period, who were first of all good constructors.

The second great barbarism of modern times is the imitation of ashlar joints in stucco; cement plastering has no limiting dimensions, as in cut stone, which is usually in courses of 18 to 24 in. height, but its dimensions may be arranged at pleasure; hence, in dividing up cement plastering, those dimensions and projections should be used, which differ as widely as possible from those of ashlar masonry. Stucco belongs to the plastic, hardening materials, whose treatment should correspond to the means employed in producing its form. Imitation of ashlars in stucco-work destroys and falsifies the structural meaning; one becomes accustomed to indefiniteness, and no longer knows how to employ cut stone, transferring to it the shapelessness of stucco whenever possible.

Finally, it should be remembered, that for purely decorative purposes, the arrangement of ashlars in mosaic patterns with elements of like form is not excluded; on Palladio's famous Basilica at Vicenza is to be found such ashlar masonry in marble, in scale-like patterns, used for a wall beneath stairs. Fig. 28.

b. Ashlar Bonds.

The most natural and free ashlar bond, both best and most picturesque, is that in which the stones are cut and set, just as obtained from the quarry, without attempting to arrange them in regular courses, or to make them of uniform height. Fig. 7 is a specimen of Grecian masonry, Fig. 29 being a similar example of Roman masonry. In case of stones quarried with good beds, but not in long pieces, like porphyry, this random ashlar bond is very appropriate, especially since it is one means of obtaining economy, and also for use in bases and substructures, supports of all kinds, fortifications, etc.

A transition to regular ashlar bond consists in making the courses of unequal, Fig. 30, or equal height, Fig. 31, but using stones of different lengths, Figs. 30, 31. Since ashlar

are subject to transverse strain, the thinner blocks must also be shortest to avoid fracture, and the higher ones may be longest, but generally, the length of the blocks should be as fur nished from the quarry. Roman, mediaeval, and Renaissance architects always preferred this natural ashlar masonry, obtaining a both picturesque and inexpensive masonry. The correct practical principle is to always work in accordance with the materials provided, so that they may be employed for the most diverse purposes, as in case of the normal brick form, and this principle prevailed from the Roman era until the 16 th century, the High Renaissance first introducing uniformity in height of courses and lengnt of stones, which was customary in Grecian temples.

The bond of similar ashlars generally resembles that of brik masonry; the proportional dimensions of the ashlars depend on the materials used and on the height of courses; their length may vary in direct proportion to the strength and height of the blocks. The simplest system of construction is that, in which the stones extend entirely through the wall; then, 1. the courses may vary in height; 2, the length of the stones may vary; thus producing the following possible combinations Fig. 32: a) courses of equal height, stones of equal length; b), courses of equal height, stones of unequal length; c), courses of unequal height, stones of equal length; d), courses of unequal height, stones of unequal length.

If a wall be composed of square stones, with those whose length is twice the side of the square, the following bonds are possible, Fig. 32, 33: e), courses of equal height, stones square; f), courses of unequal height, stones square; g), cour ses of equal height; stones alternately square and oblong; h), courses of unequal height, stones alternately square and oblg.

For economy, a, b, and g are preferable; c, d, e are more expensive and equally so; f and h are most costly of all these Bonds b and g are most pleasing of those least costly; d is most pleasing of the more expensive, and e is most uniform of all; f and h are dearer and ugly, but h is most full of variety, though appearing too fanciful, to excel the others in producing a pleasing effect by its variety. These bonds, with stones extending through the wall, are nearly similar to those composed of separate bond stones extending through the entire thickness, with other blocks only occupying a part of its thickness, which is usually made up of two stretchers, Fig. 34 i, k, or a space is left between them, afterwards filled with ordinary masonry, Fig. 34 L. Preference should be given to Fig. 34 k instead of Fig. 34 i, since the wall is wholly constructed of stones of equal size, the length of a bond-stone being determin

being determined by the thickness of the wall, one-half this being its side.

It is easy to see that in case of the most commonly employed bond, the greater the number of bond-stones used, the greater is the labor and cost, though the wall is stronger; hence they are sparingly used. If the bond-stones are to be made prominent and evident, it will be preferable for economy to finish the stretchers with projecting bosses on their faces, cutting the ends of the headers smooth or treating them as diamond panels. The richest of all bonds here mentioned, h, also the most costly, is appropriately used for a royal palace or any similar building, and if a harder material be used for the thinner than for the higher courses, there may be great variety, not only in the form, but also in the mode of dressing the stones. If we wish to be strictly consistent, the low and long blocks, subject to the greater strains, should be finished with strongly projecting diamond panels in those places most severely strained; the small and less severely compressed bond stones might be decorated in any way, with sunken rosettes, for example, if of a material easily wrought, or may be cut like precious stones, if hard stone, susceptible of a good polish, Fig. 35, n, o. The central, though lightly loaded large ashlar might have low diamond panels, and the larger square bond-stones could be finished with hemispherical bosses, or be treated like precious stones with crystalline recessed angles, as in Fig. 25. If such masonry be constructed without through stones, though the large square blocks appear to be bond-stones and really hold the masonry together, they should have projecting heads like nails or rivets, which may be formed in accordance with the hardness of the stone, or the expedients possible. Forms of bond-stones may also be improved in the mode employed by Julian San Gallo in the Gondi Palace at Florence, represented in Fig. 38, p, q.

If the masonry is to make a noble but simple impression, smoothly dressed and polished ashlars of good material will always appear best, and if the best mode of construction is also to be adopted, the ashlars should extend through the entire thickness of the wall. This kind of masonry was the normal one in the finer temples of the Greeks and Romans, and was termed Opus isodomum.

With the increasing smoothness of the ashlars, resulting in a polished surface, is likewise joined the closest possible fitting together of the bed and end joints, so that these entirely disappear if the blocks are very carefully rubbed on each other. If the material be also perfectly homogeneous, so that its color is quite uniform, a uniformity of appearance is produced, which the

produced, which the Greeks did not try to attain as being the highest ideal of masonry, or they would not have sometimes gilded the joints or have marked them by narrow strips of bronze, which appears erroneous to archaeologists, who are enthusisatic lovers of uniformity. It should then be stated, that in general, ashlar work has entirely renounced the use of square blocks; secondly, that through-stones in very thick walls should have much greater depth than width, so as not to break at the middle; a construction as in Fig. 37 r is admissible however, as it indicates the thickness of the wall by its higher bond-stones. Very durable stones with good beds, costly stones and those capable of a good polish, are well suited for the so-called plate-bond, Fig. 37 s, a peculiar mode of facing walls, not unjustifiable in exceptional cases. In veneered masonry backed by brick-work, rubble or concrete, it is evident that if no through-stone are used, the courses of stretchers must alternately extend deeply into the wall. Fig. 38 t.

If labor is to be saved on ashlar masonry, a bond with few bond-stones is preferable, and the height of courses must be as great as possible; but if material is to be economized, as in countries furnishing little stone, one has the choice of either alternating courses of stones and brick-work, Fig. 38 u as very common in Upper Italy, Belgium and Holland, or of employing alternating blocks of ashlar and brick-work, Fig. 39 v This kind of mixed masonry is sometimes found in Belgium and France, and a similar specimen of ashlar and rubble masonry exists in a buttress of the Castle of Meissen. This mixed masonry may be suitable for brick piers of churches, in spite of its inferior resistance, and it is accordingly found in the churches of Holland and S. Bavaria. Veneering walls with elements of different forms is to be considered fanciful, and may be seen in many Renaissance buildings in central France, covered with mosaic work of different colors. To this is allied Italian mediaeval incrustation in marble, which is merely a covering, and it was a merit of the Renaissance to have developed this into a structural principle.

c. Fastening and Clamping Ashlars together.

Stones are fastened together by means of mortar, as well as by projections of the blocks, three specimens of these being given in Fig. 40, shown in plan; or by dowells of stone or metal; by indenting the blocks into each other, Fig. 241; finally by cramps. These fastenings are generally concealed within the joints between the stones; if cramps appear on the external surface, they are either treated as inserted anchors and set in lead, as in Fig. 42 a, or like Fig. 42 b, from the stair balustrade of the Bishop's Palace at Lucca.

d. Ashlar Masonry in General.

The late Renaissance clearly perceived some things that have since been neglected. Bed and end joints play different parts; bed joints being subject to crushing, while end joints are not under any strain; it follows that bed joints should be made prominent, but not end joints, producing a two-fold conflict; for, 1., all architectural styles must be thrown aside, that have accented both kinds of joints, as in the best Renaissance. 2., the bed joints must be made most prominent and end joints subordinated; it would then be inconsistent to leave both joints unaccented, as both ancient and mediaeval architecture would then be rejected. If bed joints only are accented, the masonry produces the effect of being composed of continuous layers of stone, which is not at all the case.

If the masonry be considered as a construction, with a right to appear as such, it would be proper to allow it to appear as a structure composed of parts, in which the end joints would play their part as well as the bed joints; this structure may characterized in the simplest way by the natural mortar joints and does not need to appear as a monolith, in order to produce the effect of unity or as a whole, but the sway of unity over diversity must be evident in the structure itself. For the same reason, the joints should be accented by the expedients already described, and if end and bed joints are to be distinguished, which is only proper when it is desirable to make all the fine constructive points apparent throughout the entire building with most extreme consistency, end joints may be narrower and treated otherwise than bed joints.

If Semper's claim be admitted, that regularity of form and similarity of treatment are supreme requirements for the artistic effect of masonry, our hands are tied, and the finest Renaissance buildings are set aside, since a good part of their characteristic beauty is due to irregularity in form and treatment. The same is true of Semper's requirement that only the substructure, as belonging to the earth-base, should show the mode of stone-cutting and the arrangement of the joints, while the construction of the superstructure need not be apparent. We merely have the choice of either setting aside the Pitti, Strozzi and Rucellai Palaces as errors, or of establishing a theory of Art in accordance with which these structures may be considered justifiable.

By means of the various modes of cutting already described, forms of ashlars and kinds of bonds, numerous expedients are available for giving the masonry a varied character. From the massive strength of the fortress and the rudeness of the rustic building to the light gracefulness and princely spelndor of the palace

the palace, the most varied effects are possible in the appearance of ashlar masonry. The actual dimensions of the blocks and their proportions add their own effect to the general one of the masonry. Square-faced ashlars appear bolder than oblong ones, and small stones are also bolder if approximating the square form, but large stones, when oblong. Increased richness in the external appearance of ashlar masonry may be produced by the mode of cutting, by varying the bond, by refining the bosses with mouldings, rubbing and polishing, by the use of better materials, by inlays of finer and more valuable stones and metals, by decoration of the joints, etc.

As for the mode of cutting, all affected and formal treatment of the ashlars, as if the stones were stuffed cushions, like that originated in the Barocco, is decidedly objectionable. No attempt should be made to enrich the architecture by increasing the labor in any way, and if one does not wish to economize work but to lavish it, it is preferable to give the ashlars a form b̶e̶l̶o̶n̶g̶i̶n̶g̶ ̶t̶o̶ ̶t̶h̶e̶ belonging to Sculpture.

To accentuate the bond leads to mosaic work and disguises the structural character of the masonry, if carried too far.

On the contrary, if it be desired to retain a rich structural bond, like Fig. 35 o, and to carry its decoration to the highest point, as in an altar-chapel or consecrated shrine, it is permissible to use a more refined treatment of the bosses by moulding, rubbing and polishing, nobler materials, inlays of semi-precious or precious stones, noble metals, stone intarsias, decoration of joints by gilding with stamped patterns, or mosaics. A monument or a public fountain would justify the use of this kind of decoration. The corresponding sculptured decorations and figure-reliefs would require a rich mode of treatment. It not being possible to surpass this richness in decoration, we must then, which is permissible in purely decorative works, abandon construction and either merely think of a covering composed of sculptured marble, like the facade of the Certosa at Pavia, or incrust the surfaces with polished precious stones, whose joints are gilded and decorated by stamped patterns, as in thecchapel of Castle Carlstein near Prague or lastly, cover the masonry with decorated plates of bronze or ofnnobler metals, as done in Greece in ancient times.

A peculiar construction of stone walls may be mentioned here entirely correct in principle and admitting of a great variety of forms, an example of which may be found in the Romanesque church of St. James at Regensburg, Fig. 43; the wall is composed of stones not extending through its entire thickness, but so arranged that part project on the front and part on the rear sides. The panels are enclosed by an architrave of suit-

able profile, and the convex portions of one side become concave on the other. This structural motive may be treated in various ways, according to the bond selected, and thinner and more decorative enclosing walls may employed in this manner.

As opposed to ashlar masonry, whose nature is entirely structural, bonds imitating ashlar work in constructions of wood, Dutch stove tiles, wainscoatings, metal work, etc., are to be so treated if possible, that they may not suggest actual ashlars. Sunken panels, sometimes appropriate for stones under pressure, more richly profiled enclosing mouldings, etc., are not only permissibles for structures of materials other than stone, but are even to be preferred. Divisions into ashlars, painted onpplastered walls, must be treated in a mannerppurely decorative, so as to appear like tapestries sewed together. Each division should be enclosed within a decorative border, its centre being accented by flowers, rosettes and other ornaments.

Chapter 2. Brick Masonry.

Brick walls are found in the earliest period among the Assyrians and Chaldeans, who employed unburnt bricks, generally laid with asphalt. Yet the Romans first developed brick mason ry; with excellent clay and superior mortar and cement, they quickly constructed all kinds of mixed masonry of concrete, and of rubble, where brick was chiefly employed as a facing for the wall; for this purpose, they used partly triangular, partly prismoidal tiles, generally employing oblong tiles for through courses of headers, and triangular ones for the facing stretchers, behind which the wall was a mass of concrete, composed of fragments of tiles and cement. They preferred the Opus spicatum, as well as a kind of masonry, in which patterns of all kinds were produced by horizontal stripes of color or by colored stones.

During the Middle Ages, brick construction was developed in different ways in various parts of Europe, especially in Italy S. France, Bavaria, the low plains of N. Germany and in Holland. Only N. Italy and N. Germany have created a true construction in brick, other countries having almost exclusively employed a mixture of cut stone and brick-work. A bond was used in Holland during the entire Middle Ages, composed of alternating courses of stretchers and headers, though the lengths of the bricks did not correspond to their widths, so that regular breaking joints in each second course was not possible.

The middle portion of the wall is usually composed of rubble backing. The natural mode of treatment is to lay alternate courses of stretchers, and if two end joints fall together, a

longer or shorter brick is selected, or is suitably cut. This kind of masonry has the decided advantage of cheapness, over all regular bonds, and is therefore to be recommended for ordinary purposes. It appears picturesque and less pretentious than regularly bonded masonry. (Most American stone-faced walls are wholly backed with common brick-work, rarely rubble.

1. The Structural Bonds.

Modern bonds are either those used during the Middle Ages, as Gothic or Polish and Dutch or Flemish bonds, or those introduced with the Renaissance, as the Cross and Block bonds.

Ordinary modern brick masonry is composed of bricks of uniform dimensions, whose height, breadth and length have the proportions 1 : 2 : 4, including mortar joints, so that 4 thicknesses and 3 joints equal the length (except in the U.S.). Bats are sometimes used with whole bricks, as in Fig. 44; half bricks H, two making up the length L, quarters V, three-quarter bats D, and also split bricks K, two making the width of a brick. Each bond is so arranged that the bricks forming the external surface of the wall, are stretchers or headers, and they always cover the joints in the course next below them.

The thickness of brick walls is always a multiple of the width of a brick, no others being in use. The end joints of the wall surface commonly extend through the wall (except in the U.S.), Fig. 45 a. The interior of the wall is entirely composed of headers, stretchers being only used on its external surface. (Reverse is true in U.S.). If the thickness of the wall equals an even number of half bricks, the courses are always similar on both faces, Fig. 45 b; but if uneven, the courses alternate on the faces, a course of headers on one corresponding to one of stretchers on the other.

If terracotta blocks or cut stone be used in connection with brick masonry, their heights must always be multiples of the thickness of a brick(with its mortar joint). These are briefly the most important points in regard to brick construction.

We will next consider the bonds of facings of walls, then those of angles, and the decorative motives resulting therefrom.

a. Block Bond.

The bond is so arranged that end joints of all stretchers and headers alternate above each other, Fig. 46; any vertical element of the wall being composed of alternating stretchers and headers. If the bricks are distinguished by different colors, Fig. 47, the bond forms connected vertical linear element between which interspaces are left. Used diagonally with bricks of two colors, it chages the bond into a net-system. Numerous decorative patterns in various directions may be produced by using bricks of different colors, Fig. 48. (Usually

called English bond in the U.S., but rarely used except for ornamental work in two or more colors.)

b. Cross Bond.

Like Block bond, Cross bond consists of alternate courses of headers and stretchers, but end joints of stretchers only fall in the same vertical in each fourth course, and those of headers in each second course, Fig. 49. The entire bond may be considered as a diagonal net-system, with filled cross-shaped interpsaces. In vertical, horizontal or diagonal directions, this bond merely consists of abutting courses. It gives rise to the most varied decorative patterns, and band-like or net-like motives of all kinds. (Also called English bond in the U. S., no distinction being made between this and the last).

c. Gothic or Polish Bond.

Headers and stretchers alternate in each course, Fig. 51. In a vertical direction, the bond may be divided into connected elements, which fit together without any interspaces; in a horizontal or vertical direction, into detached courses, or diagonally into a net-system, in which patterns are produced by separate headers, as in Figs. 51, 52. (Called Flemish bond in the U.S. and sometimes used in ornamental work).

Besides Gothic bond, a variety of it is not uncommon in the brick construction of N. Germany, the so-called Wendish bond, where two stretchers alternate with a header in each course.

These mediaeval and other bonds produce a very rich variety of decorative surface patterns, though entirely different patterns are peculiar to each one of them.

d. Flemish Bond.

The Flemish bond, Fig. 53, incorrectly termed Dutch bond, is in common use in Belgium and rare in Holland, consists of alternating courses of headers and of courses in Gothic bond. The end joints of each second course of stretchers and of each second course of headers lie above each other. In a vertical direction, this bond consists of connected elements without interspaces; horioznatally, of detached courses; diagonally, of a net-system with cross-shaped meshes. This bond likewise producesspeculiar decorative patterns. Block bond is the one most commonly and generally employed in masonry. (Common American bond consists of a course of headers alternating with 6 courses of stretchers).

Cross bond is stronger than Block bond, on account of the more perfect alternation of the joints. Gothic bond is chiefly used for facings of rubble walls, has less strength than Cross bond, and is not so good for facing rubble masonry as a bond composed of stretchers and headers alternating in pairs, Fig. 54, so that two courses always bond together with the ... of the wall.

backing of the wall. Dutch bond is rarely used except for walls one brick thick.

The decorations of structural bonds are really patterns, always corresponding to those of surface embroidery. According to the old Dutch method, still to be seen in a few buildings, the masonry is decorated by borders and bands of various patterns, Fig. 55, produced by the bond itself.

It is evident that if a bond is to terminate at the angle of a wall or against an architectural member, and it be cut vertically as on lines a b, c d, e f, Fig. 56, (through end joints or centres of the bricks, quarter bats will be required at the ends. Since the wall should be made as strong as possible, the use of quarters and split bricks should be avoided at angles, so that each course should commence with at least half bricks, the quarters and split bricks being placed at some distance from the angle. Care must be taken to prevent two end joints from falling together in two adjacent courses.

If two walls join at right angles, the bond should be so arranged that in each alternate course A and B, one wall always extends clear through the other, which abuts against it, Fig. 57 A, B. According to the preceding, the angles are to be so arranged, that there may always be as many three-quarter bats at the angle as there are half bricks in the thickness of the wall, Fig. 57, for if but one three-quarter bat were used at the angle, followed by two whole bricks in the heading course, the principal rule for bonds would be violated, that the end joints should extend clear through the wall. (Not in U.S.).

Courses alternate in Block bond as shown in Fig. 58. In Cross bond, the fourth course is shown in Fig. 59, the others being in Block bond. The bond varies in the interior of the wall, according to whether the thickness of the wall is an even or uneven number of half bricks, and the principle that each course is continued through the entire thickness of the wall, alternately, is not strictly retained in Cross bond.

In Gothic and Flemish bonds, properly used only for facings, it is not difficult to make the arrangement of the bond clear. It is easy to commence this bond at angles with three-quarter bats instead of half bricks.

What has been said of the decorative treatment of ashlar masonry is in part applicable to brick masonry, but from the smallness of its elements, this can never give the impression of robust strength, but rather, like a net-work, suggests the idea of impenetrability by the intimate connection of its small blocks and its proportionally wide joints.

Decorative expedients for the structural bonds are based upon: 1., the use of bricks of different colors; 2, the greater

prominence of the bond at the angles; 3, the projection and depression of individual bricks and patterns; the thickness of the wall may be indicated by the bond at its angles.

Like the stone wall shown in Fig. 43, brick walls may be constructed with panels raised on one side and sunken on the other in patterns suited to the bonds, Fig. 60, especially in 1-2, 1 or 1 1-2 brick enclosing walls, without cutting the bricks. Finally, a portion of the brick walls executed in patterns may be left open, as in case of parapets, garden walls, friezes for admission of air and light into ordinary buildings with thin walls. (Sometimes used for balustrades, windows, filling gables, but rare in U.S.).

2. The Decorative Bonds.

When the structural idea entirely disappears, as in the various panels and facings of walls, the most varied decorative bonds become possible; they may be used as facings for either structural bond with the aid of quarters, halves and split bricks, and they may also be executed with or without the aid of cut or colored bricks. The simplest form of purely decorative bond, capable of producing the most varied patterns, is that in which each stretcher is replaced by two halves, Fig. 61, so that but a single kind of bed joint appears on the face of the wall. (Commonly used for circular chimneys in U.S.).

An entire series of decorative bonds form true we-systems, Fig. 62, others being mosaic systems of the most varied kind, according to whether the bricks are cut or uncut. Fig. 63.

Joints in brick-work are usually so broad, 1-8 to 5-8 inch, that their influence on the external appearance of the wall is very decided. In the better kinds of walls, they are pointed with strongly hardening mortar or cement, using different profiles of joint according to circumstances, Fig. 64. Modern masonry in Holland is characterized by the use of very small bricks, as well as by having end joints not more than 1-8 in wide, while bed joints are 5-8 in wide; the joints are very carefully worked to the profile Fig. 64 d, almost without exception, and are usually left white.

It has usually been customary in Germany to color the mortar before using, so that any desired color tone may be given to the wall by means of the color of the bricks and that of the mortar. The bricks are generally of a broken color, dark brown, black, red, yellow, white, with green or violet obtained by glazing. By comparing carefully executed masonry of different localities, it is evident that a white or approximately white net-work of joints appears best, when the bricks are of a dark color. Dark joints are suitable for very light bricks. Older houses in Amsterdam were built of black or peat-brown , as well as of

as well as of deep reddish-brown bricks, but the joints were always left white, and the wood-work of the windows was also white or nearly so. It is undeniable that the appearance of such gloomy houses is made as pleasing by the joints as may be possible.

The imitation of ashlar masonry in brick-work, as exceptionally done in the Italian Renaissance, is nonsensical. (Mortar joints are frequently colored in the U.S., black, brown or red dry or paste colors being mixed with the mortar, which produces a more pleasing and less crude effect than the use of white mortar. Inferior brick walls are also stained and tuck-pointed in white, which is one of the worst of shams, and is never durable).

Chapter 3. External Plastering of Walls. (Stucco)

Since external plastering is a protecting covering for ordinary rubble or brick masonry, it is to be treated merely as a covering, and its range of form is to be sought entirely independent of masonry. All imitations of ashlar and brick masonry, painted or in relief, are decidedly objectionable for this reason. The expedients, that may be employed for decoration of external plastering, are those of Sculpture and Painting, the stucco being a soft and plastic mass, when applied.

Stucco-work is then the proper means of decorating external plastering, a division into panels, the enclosure of panels by mouldings, inserted ornaments in cement or plaster, etc., are permissible, but only under the condition that the series of forms may imitate neither those of stone nor wood. All stamping or incising in the soft mass is well suited to the nature of the material; the inscription or impression of ornaments, a rude treatment of the surface by hatching or roughening, by sgraffito, or by true painting, gold grounds and gilding of the various parts; all are suited to the plaster surface. A painted and symbolical architecture is preferable , which is no imitation, but a free play of form, can not be excluded from the domain of plaster decoration. Plastering subserves no monumental purpose in general, and therefore affords free scope for the taste of the period or the individual, or the treatment due to the subject, and for this reason, itmust be excluded from monumental structures as far as possible.

One of the many barbarisms of the "Periwig-and-Pigtail" period, which we adopted, and has not yet disappeared, is the painting of cut stone and brick-work in oil colors. Itis one of the faults in taste of the last century, to be opposed by any means, though one should not forget that the esthetic sense in its lowest stage of development, as in case of the general

general public, sees more art in cleanness of appearance and regular, symmetrical arrangement, than in the picturesque; the modern peasant is better pleased by a regular avenue of poplars, than by the finest forest; art commencing for him, as for mankind in general, with order and neatness. It is to be lamented that he remains at this beginning point, and that the great public of cities and entire nations, like the Hollanders can never pass beyond this, though we must consider this love of order and neatness in nations as really estatic, without which an exaltation to Art is generally impossible.

In many cities, where available materials are not homogenous it is often scarcely possible to convince even educated persons, that the natural color of the material, in spite of its irregular and possibly gloomy color, is preferable to a uniform coat of oil color. The reason is that order and neatness is recognized as a canon of beauty by theseppersons.

As being not unimportant and entirely useful decorations of masonry, we have finally to mention wall-anchors, as well as holders for banners, lanterns, etc., the former being found on almost all old houses in Holland, the latter, on the palaces of Florence and Sienna. The Dutch and Tuscan smiths emulated each other in the designing of tasteful works of this kind, which are to be accepted as true models of a refined treatment of metal.

(Stucco plastering is rarely used in the U.S. because plain stone facings are no more expensive, look better, and are probably more durable. When used, imitations of the Orders shou should be avoided, though almost invariably employed in Europe for this purpose. The Renaissance styleis best for the case)

Chapter 4. Wooden Walls.

According to the construction, wooden walls may be supporting walls, like those built of horizontal or vertical timbers or of planks, or they may be merely division walls, such as partition or board walls, paling or picket walls, panellings or lattice-work.

1. Walls composed of Horizontal Timbers.

These are built of round or rectangular timbers, laid to cross each other at the angles, either leaving crevices between them, as in Alpine stables and hay sheds, or to form walls that are wind and weather proof. The ends of the timbers project beyond the surfaces of the walls at their intersections, or are cut off flush, making the bond visible at angl

Decorative expedients for esthetic treatment of these log-walls only consist in carving either joints or surfaces, or both joints and surfaces of timbers; also in carving the projecting

jecting ends of timbers, their bottoms or sides, their angles, edges or ends; finally, when the ends do not project, the angle bond is itself decorated. Even if a richer treatment of these walls is found in exceptional cases, these decorative expedients are always worthy of mention. The true Swiss cottage, Norwegian and Russian churches, as well as peasants' houses, constructed of horizontal timbers, and also mediaeval constructions of similar kinds, all employ the most varied forms of wood-carving. The carving of the edges of the timbers may be done in various ways, either by mouldings, Fig. 65 a, or by notches of all forms, whose repetition produces patterns of numerous kinds, Fig. 65 b. The carving of the surfaces embraces borings and incisions of all kinds, dentils, diamonds, chess-board and zigzag patterns, and the innumerable kinds of ornaments for enriching surfaces and edges of timbers. Fig. 65c One of the best means of decorating surfaces of timbers is by incised letters, proverbs, etc., or by raising these above a sunken ground.

It is self evident that the bed joints of the timbers can be so profiled as to be tongued into each other, Fig. 66, as in Norwegian and Russian buildings, whose walls are required to be absolutely air-tight; the ends of the timbers then show the form of the bed joint. These ends may be formed in the most diverse ways by carving their side and end surfaces, Fig. 67, or by carving them into any peculiar forms.

Which one of these modes of decoration in wood is to be preferred, depends on other circumstances, on the richness of the decoration, whether the structure is to be an elegant temporary building, like the pavilions of an Industrial Exhibition, or whether it is to be as monumental as possible, and is therefore required to resist the effects of the weather as strongly as possible; the choice of form must be quite limited in the last case, as complex forms of carving afford opportunity for the collection of rain water and consequent decay of the wood. Russian wooden architecture sometimes uses timbers, not of rectangular, but hexagonal section, Fig. 68.

(These log-walls were formerly much used for log cabins in the U.S., but were rarely decorated, though very neatly built in some places, especially in Kentucky).

2. Walls composed of Vertical Timbers.

These are almost wholly employed in buildings for ordinary purposes, seldom for those of any importance. They are composed of timbers set vertically and closely joined together by tongues and grooves, Fig. 69, usually for preventing admission of water. The timbers are driven into the ground, or their ends are tenoned into a sill and a plate. The idea of decorating this kind

ting this kind of wall would never occur to any one. But if it be desired, the joints between timbers may be covered by moulded battens, be made apparent by carving, but not so as to weaken the timber or to permit entrance of rain. The timbers should be decorated by raised ornaments between the battens, and the plate should be treated with patterns in bands.

3. Walls composed of Boards.

These are almost entirely used for thin partitions; they either consist of a frame-work into which panels are inserted; of two thicknesses of boards nailed together, their fibres crossing at right or acute angles, Fig. 70,; or are composed of a single thickness of planks,—abutting, tongued together, or overlapping, supported by vertical posts and horizont. girts

In case of two thicknesses of boards nailed together, it is most tasteful to lap the joints, Fig. 71, as no crack is then caused by shrinkage of the wood;—moulding the joints, and a regular spacing of the nail heads has a deceided influence on the general effect. If this mode of construction be used for doors, they should be bordered by strips of sheet metal, or be completely covered with sheet metal, leather or parchment; the doors of mediaeval churches were frequently treated in this way, and doors of Italian Renaissance churches and palaces were sometimes covered with thin metal. The edges of the bordering metal strips may be cut out in the most varied patterns the nails changed into rosettes, or their heads formed into large and effective knobs; the plate covering may take the mediaeval form of horizontal strips, each edge being cut into some form of linear division of surface, Fig. 72, or be covered by firmly nailed plates, like Renaissance doors, in which nails form a separate decorative system, or the whole may be arranged in any other manner.

Fences or enclosures of boards—or planks generally serve for only temporary or necessary purposes, not admitting of an artistic treatment. If they are to be decorated, according to the mode of construction, we may: 1, mould the joints; 2, cut the overlapping edges of the boards in patterns, Fig. 73; 3, cut moulded grooves in the boards, which are matched together; 4, mould the boards themselves in mediaeval style, Fig. 74;. The upper and lower margins of isolated forms are almost always treated like Figs. 73, 75, that are subject to the general rule, that forms should be avoided, which might cause the projections to split off.

To these board fences should be added parapets and balustrades of galleries, bridges, etc., as well as paling fences. Balustrades form bands composed of vertical elements, held together at top by a horizontal rail, their lower ends tenoned

into another rail or held together by a pair of strips, Fig. 76, so that the boards may be cut into free-ending forms, this cutting partly consisting in widening the joints, Fig. 75, and partly in perforations of the boards, Fig. 76. A correct feeling led those nations that most completely developed wooden architecture, The Swiss, Tyrolese, Upper Bavarians, Russians, and Norwegians, to generally treat the cuts in the boards in rectangular forms, like lace and embroidery patterns, or to so form curved cuts as to merely indicate free play of line, avoiding determinate forms of plants and animals. Many modern fret-sawed forms of our wooden architecture are therefore objectionable, because imitating outlines of objects in an unsuitable material, and which may be painted on but not fret-sawed; and further, since it is forgotten that in the first place, these cuttings depend on a finely balanced division of the surfaces removed and left, but never on the imitation of any definite thing. (Fret-sawed work is still very commonly used in the U.S., but is generally of bad design.)

Only in exceptional cases, such as wooden brackets, acroteria and similar details, are heads, animals, and plant forms to be employed, as well as ornamental objects in general with curved lines, and they are then to be treated with exceptional delicacy. This requirement for wooden architecture is easily justified. The fibres should be cut as little as possible, and not so that parts of the wooden decorations may drop off; the wood should also form a coherent net-system. If it be desired to saw any ornament in a board lake a stencilled ornament, the fibres are not only improperly cut, but the very refinement in the movement of the ornament, the leaf-points and smaller forms, are sawed out with difficulty or incorrectly, the thickness of the board hindering the free management of the saw. Complicated fret-sawed designs are only suitable for sheet metal or very thin boards, seldom used in wood-work.

Sawed-out ornaments appear dark or light, and are perforations generally sunk like black spots on a light ground; they attract more attention than the wood and require proper form-treatment; it is preferable to so form them that the remaining wood may take proper forms. Exactly the opposite of what is here said is true of carvings in boards not cut clear through, one then having perfect liberty to do as he wishes. If perforated boards are nailed on other boards, forming a kind of decoration in relief, the board forming a net-system, the same freedom is possible as in case of imperforate carvings, as the more fragile parts are firmly nailed. The finest Swiss houses and those in the Tyrol and Upper Bavaria have adhered to this primary law with great consistency; perforations

are almost entirely openings of pleasing form and arrangement, the free ornament being used on friezes, panels and similar ornamental parts as a board nailed on. Either the perforated or the nailed-on board may be carved to produce a sculptured effect, or it may be decorated by painting. But one expedient of the poverty of modern thought is to be rigidly excluded, though in spite of ugliness it always passes for a mode of increasing the beauty, the chamfering of angles and the outlining of forms by a colored line. It is singular that this error in taste does not disappear, but our schools still prize it as a specimen of refined taste. The most pleasing form is thus weakened and ruined at an increased cost, and to make it especially beautiful, a bold red band is then drawn parallel to the ugly edge, so that the form retains still less character.

4. Paling Enclosures.

Paling enclosures include simple park fences, consisting of verticals placed close together and supported by horizontal timbers, and present different modes of treatment. They have means of producing the most diverse forms by the careful selection of timbers of equal or alternately equal diameters, by the substitution of pleasingly interwoven willow twigs for the horizontal timbers, by the simple carving of the upper ends of the verticals, and by partial removal of their bark. For park enclosures, poultry yards, enclosures in zoological gardens, etc., this simple motive admits of pleasing variations in many ways, and if the wood-work, whose principal color-effect is due to the color of the bark and of the wood of the denuded places, be heightened by interwoven brightly colored twigs, Indian red being used on parts of the pieces, and the openings between the verticals be filled by fine lattice-work, as required, these simple elementary ideas may be developed into an inexhaustible wealth of form treatment.

A peculiar use of paling-work is found in Upper Austria and Steiermark in hay sheds and similar buildings; the simple fram frames of the sheds are filled-in with thin fir poles, making the sapces between the frame appear striped, Fig. 77; these stripes may be varied in many ways. This kind of wall has recently been employed for rustic buildings, zoological gardens, etc. Ordinary lattice partitions, used in all kinds of ordinary buildings, are variously treated by notching the edges of the strips. An inexhaustible number of motives may be produced, governed by the principles given for ornamental cutting of boards. Fig. 78. The strips may also employ all expedients of carving, thereby being changed into works of low relief in wood-carving proper; round pieces, obtained from natural trunks, may also be transformed by carving into true sculptures

tures in wood. (Picket fences belong to this class, are of numerous forms, and are very commonly employed in the U. S. for enclosures of grounds in cities and villages. Now frequently constructed with vertical wires and wooden rails, producing a light and delicate effect. A recent type substitutes wires for horizontal wooden rails, the verticals being interwoven between them, and might be made quite ornamental).

5. Panel-work and Lattice-work.

Panel-work is always composed of a thicker frame-work and thinner panels; the framing forms a kind of net-work, and the panels may be grooved-in, fastened on as a lining, or lastly, may be entirely omitted. Materials of the panels usually wood which may be replaced by marble slabs, plates of engraved or cast metal, slabs of slate, electrotyped plates, majolica plaques, pieces of glass, parchment, cloth, etc., according to the purpose subserved by the panelling. We will now consider in detail the formation of the frame-work, the construction of panels, simple panels and their materials, treatment of joints panel mouldings, etc., the various kinds of lattice-work, and lastly, the purposes to which panel-work and lattice-work are applied.

Panel-work is constructed of small pieces of wood by connecting one series with the other by mortises and tenons or tongues and grooves, etc.; almost any net-system may be used for panelling, as a basal form. The essential requirement for the pieces is, that they must be narrow, so as to shrink but little; the same is true of all wooden panels, which shrink less, the narrower they are. Hence the frame-work is divided into many combined panels; when the frame is to be very wide, with narrow panels, solid tongued-and-grooved mouldings must be inserted between the frame and panels, Figs, 79, 80.

The decoration of the frame-work must be in accordance with the principles established for bordering or enclosing surfaces It is usually moulded and decorated by carved or inlaid ornaments, and also decorated by metal knobs, placed at the intersections of the pieces or by metal trimmings. The richest panel-work is found in the joiners' work and cabinet work of the Arabs (Mohammedans), and of the Renaissance.

If the panels are each composed of several parts, they may be combined in accordance with any suitable mosaic system, Fig 81, then usually requiring strengthening by a second thickness of boards at right angles to the panel. The panel may be composed of two thicknesses, each covering the joints of the other, Fig. 82, a favorite motive in mediaeval work. Finally, panels may be partially or wholly replaced by mouldings grrooved-in, or special rails and muntins may be inserted, the groov

ed-in mouldings being broken around between them, Fig. 83. Italian Renaissance wooden doors and ceilings used these motives in various ways; the use of grooved-in mouldings and special rails and muntins affords this advantage, that finer kinds of wood can be used, when not of large dimensions, and that the panel-work appears both rich and strong, but both labor and cost are increased.

Joiner's work now employs other materials than wood less frequently than it might for panels of panelling. Wood is always necessarily used for panels subject to direct strain as in doors, wainscoatings and similar work, where they may be broken or pressed in. To increase its direct strength, its middle portion should be strengthened, either by mediaeval vertically moulded raised panels, stopped at their lower and upper ends by carvings in many forms, or by Renaissance diamond panels, like those used for diamond-panelled ashlars, though one must be as careful as possible to keep their forms as distinct as possible fromthose employed in stone construction.

To this use of ordinary woods for panels may be added that of costly woods, of intarsias, and all kinds of inlaid work. One of the best materials for panels not exposed to injury is smooth stone of fine color and polish, easily obtained in many localities. Not only different marbles, but various kindso of quartz, serpentine, lapis lazuli, as well as fluor spar, crystals of glass and stained glass, can be used as panels, with thin slabs of engraved slate, etched lithographic stones, and any other suitable materialor artificial minerals, true sculptures, reliefs, etc. (Stained glass is now much used for panels in the U.S.). We may also use plates in relief of cast, hammered or electro-deposited metal, enamelled plaques, etc., the products of metal work and art industry, faience and majolica, porcelain and glass, the latter transparent and with engraved or etched decorations, stained, gilded, or opaque glass in form of mirrors; also parchment, stamped leather, silk, velvet, cloth, lace, gold brocade, embroidery and toher textile materials, lastly, paintings on canvas or other materials. (Most of these would only be suited for furniture or interiors

The pieces of the frame are connected by joints at right, acute or obtuse angles, and are side, cross or intersecting pieces; it was a mediaeval rule to decorate insets and tenon joints in some way, Fig. 85. This is especially true of common wooden doors, that were decorated in the simplest way; these decorated joints, such as are found in mediaeval and Swiss houses, are worthy of use at the present time.

The treatment of the joints between the panels and the framework is based on the requirement that the panel shall not be

tightly inserted in the framework, but so as to freely expand and contract without danger of cracking and warping; if panels are made of ordinary wood, as usually the case, and which shrinks readily, the wood-work must not be painted, since a line of a different color would become visible by shrinkage of the panel, and the joint must be covered, that the expansion and contraction of the panel may not be visible. This may be done by moulding the edge of the frame-work, placing a round next the panel, or by fastening a round or moulding of wood or metal to the edge of the framing, Fig. 86. If the wood be merely left in its natural color, oiled or coated with transparent varnish, the joints will not be visible, and the rounds and mouldings are unnecessary. If it be desired to paint a part of the wood-work, only the frame-work and panels are painted, leaving the mouldings in the natural color of the wood.

The mouldings of the frame-work and panels are arranged in accordance with the following considerations: they are struck with a plane in a great variety of forms; if the panelling be in the interior of a building and is then chiefly lighted by diffused light, strongly curved profiles are required, while moderate relief is sufficient for exteriors. The darker the wood-work and the more distant it is from the eye, the greater must be the relief of the profiles; polished woods, shining paint, varnish and gilding are suited to the lowest relief.

The frame-work is to be so arranged, that the material may appear more prominent around the margin of the surface, or as if receding from a centre, which is left less prominent, and this determines the profiles of the pieces froming the frame-work, in connection with principles already stated.

Without taking any special style or the ancient Orders as a basis, but according to the preceding views, the profiles of the frame-work and mouldings may be composed of simple forms of section, that must always be used by man. These simple forms of section are:, Fig. 87: 1, chamfered angles; 2, rounded angles; 3, hollows; 4, combined rounds and hollows; 5, combined hollows and rounds; 6, rounds; 7, grooves; 8, combined rounds and coves.

Variations of these ground forms may occur in three ways; a), by a curvature of profile more or less strong; b), in case of combined forms, one, or neither of the two is most prominent; c), when the form is not only treated as a connected , bu but also as a transitional form, as in case of a curvature varying from that of a circle. Fillets, grooves, and small hollows, serve to separate different members, at the same time being bands to connect them; the plain flat surfaces adjacent to these members serve as a contrast to the mouldings.

One of the most decisive reasons existing now, compelling us to do one thing and to avoid another, is the question of cost. We are always restrained in the treatment by a thought of its cost, and seek to obtain the greatest effect by the simplest means. The Renaissance most fully developed panel-work, and we shall learn most from it for the treatment of our own.

For effect of contrast, forms of profiles must alternate; where alternation is not found, overloading is produced, which commences with duplication, and produces the effect of monotony and poverty of thought, instead of richness (except in reedings or flutings). Such duplications should be considered only when desirable in exceptional cases for sake of economy. In case of wooden mouldings, this reason of economy entirely disappears, their cost being approximately equal for working. Rounds and deeply undercut forms require more labor and are then to be avoided or limited to exceptional cases. The Gothic employed hollows and rounds more than any other style, but made very marked differences in the radii and sections of the curved forms to obtain effective contrasts. The requirements of contrast and variety are satisfied if a concave follows a convex moulding, or the reverse. Hence, in concavo-convex forms of section, a quarter-round or round may follow a cove, but not another cove.

We must further consider which profile form shall predominate whether concave or convex. Concave forms not only convey the impression of attraction, but also, that of ~~change~~, being transitional forms; but convex forms express energetic repulsion. Concavo-convex, like the ogee, are intermediate between the two, the sharp contrast of convexity being softened.

The finest frame-works of the Italian Renaissance enclose the entire work by a border moulding, which takes a form according to circumstances; the pieces composing the frame-work remain flat, or form a sunken ground, Fig. 88, or are decorated by intarsias, sculptured ornaments or band-like designs. The richest ornamentation is concentrated on the space between the border and the panel; this member not seldom consists of pieces bordered on both sides by mouldings and finished as diamond panels, Fig. 89, or are decorated by band-like ornaments. The panels are either left plain, or are finished with raised diamond panels, or finally, are decorated by beautiful sculptured rosettes. The later Renaissance sometimes surrounded the panels with very strongly projecting forms of mouldings, causing an appearance, as if the material very forcibly drew itself away from the panel.

In the richer forms of joinery, the cornice was decorated by a corona with carved leaves, after the antique, the astragal

was beaded, and the cavetto was ornamented by incisions. There is no reason for omitting these antique leaf-mouldings and beaded astragals from our work.

Panel-work is preferably employed for doors, windows, shutters, wainscoting, furniture, wooden ceilings and partitions.

6. Lattice-work.

Panel-work becomes lattice-work if the panels are omitted. Ordinary lattice-work is either constructed by placing strips across each other, or halving them together; or if the strips are very thin and flexible, they are interwoven, Fig. 90. In the first two cases, the intersections of the strips are fastened by nails, but a fastening is unnecessary in the last case. The lattice-work may be completely enclosed by a frame, or be suspended so as to be free; the strips may be horizontal and vertical, Fig. 91, or inclined; lattices constructed of strips crossing each other or halyed together take many forms, if the separate strips have their edges cut out in accordance with any linear ornament, Fig. 92 a. Moorish and early Italian architects have shown an especial preference for these lattices.

A second mode of decorating lattice-work is mediaeval and consists in cutting the edges of the strips at the openings only. These cuts may form complete perforations, Fig. 95, or they may be only carved, the openings retaining their square form, Fig. 96; this motive was much used during the entire Middle Ages for doors, in which the interspaces were closed by a thickness or lining of boards, and even for panel-work with panels of majolica plaques and tiles, and also for walls of gabled houses, as at Beauvais. The Renaissance retained the same motive for the construction of doors, as in a church door in Deventer. It is evident that the strips end free if not enclosed by a frame, and the nails at the intersections may be transformed into knobs and rosettes of metal. Rules already given are applicable to the frames.

A peculiar form of lattice-work was invented by Oriental nations, first used by the Chinese, employing bamboo stems; these lattices consist of separate round members, tenoned together, Figs. 97, 98, and form knotty swellings at their joints, that aid the artistic effect. A transformation of this to a lattice composed of flat strips, also a favorite with Orientals, gives rise to the most varied forms, according to the mode of intersection of the strips, Fig. 99, and to the way in which the knots of the bamboo are replaced by carvings of all forms, as in Arabian and Early Italian lattice-work.

A further development of lattice-work was made by the Arabs by using turned or carved pieces of wood instead of bamboo stems or wooden strips, and which were connected by holes and

tenons, Fig. 100. (Specimens of these very graceful lattices may be found in Eber's Egypt. Often now termed spindle-work and considerably used in best interior finish of most expensive houses in the U. S, screens, etc., though quite expensive). Web, embroidery and mosaic systems may be used as bases for lattices of this kind, which may also be produced from wire gauze with interwoven turned forms. A great many Arabian lattices are based on a combination of chain with lattice and other systems; it is impossible to exhaust this mode of constructing lattice-work, with its endless possibilities, but the forms may all be referred to a few simple principles.

New combinations of lattice-work can be made by making its principal lines a net-work of wood-work, the interspaces then being reduced in size by ornaments of wire, wrought iron, or decorations in cast metal.

The uses of lattice-work are particularly for light enclosures, partitions, or to serve as supports, like lattice girders; it is also excellent for graden pavilions and enclosures poultry yards, and similar purposes.

Chapter 5. Half-Timbered Work.

This is a mode of constructing walls, whose form would class it with panel-work, yet from its nature, it belongs to wood construction proper, since its different elements play an entirely different part in construction. These elements are as follows, Figs, 101, 102; on a sill a as a base are set posts c connected by a plate b. This frame-work would not be of stable form unless the timbers a and b are stiffened by struts or braces d; the girts e stiffen this bracing and divide the half timbered work into smaller panels. It is now customary to make this work as regular in form as possible, using only straight timbers, thereby sacrificing the advantage of variety in effect, and obtaining scarcely any improvement by more perfect and stronger construction, which remains nearly equal to timber-work regularly arranged as in Fig. 101, or irregularly as in Fig. 102.

The motives for the esthetic treatment of half-timbered work are derived from the form and arrangement of the timbers; from the mode of their intersection, and from the mode of filling the interspaces. The timbers may be arranged in various ways, and a difference should be made by using regular or irregular panels, braces and girts, according to whether the purpose be more structural or decorative. Pugin gives Fig. 103 as found in houses at Boulougne. An alternation of different arrangements of panels will always have a more pleasing appearance, than if all are treated in exactly the smae way. The most

pleasing half-timbered houses exist in peasant villages and small cities in those countries, where wood construction is preferred, frequently showing very instructive details, and are evidences of a true art feeling in their builders.

The use of naturally or artificially curved timbers in wood construction, or those cut into curved forms, may be very ancient; they have wrongly been discarded in our era. The wooden architecture of the Tyrol, Upper Bavaria and Switzerland favored this means of obtaining pleasing forms in wood-work. A few examples are here added from houses of Hessian peasants, Fig. 104.

If faces of the timbers are to be decorated, as struts are subject to compression, they are to be ornamented by incised or painted longitudinal stripes, like columns, and their ornaments may end in volutes; but ties are in tension and are to be characterized by band-like patterns. The intersections of timbers can be decorated as described for panel-work, as usual in mediaeval and Swiss wooden architecture, Fig. 104, right. The interspaces of half-timbered work are either filled with a covering of boards, which is most pleasing if placed on the inside of the wall, or by unplastered brick-work, for which a purely decorative bond is especially appropriate, or lastly, with plastered masonry(or plastered on lathing in modern work This plastering may then be decorated in any of the ways mentioned in the chapter on Plastering, such as by incised sketches, sgraffito, ornaments in relief or painting. Work of special elegance has interspaces filled with tiles or terracotta.

In addition to a consideration of the construction of walls, we have yet to mention covering the walls with slates, shingles, tiles, etc. The mosaic system is the basis of all these modes of covering walls and various motives may be derived fr from the linear division of surfaces into similar elementsF105

Chapter 6. Non-Vaulted Stone Ceilings.

The ideal of ancient architecture was the construction of ceilings with beams and slabs of stone, and this has lost nearly all practical value for our time, though retaining a symbolical one. From a standpoint purely material, recognizing only what subserves a material purpose and stripping off every historical reminiscence, we should then throw the stone-beam ceiling aside, since we can attain the desired end better and more cheaply by vaults or iron construction. But from a general point of view, where we must correctly distinguish between what has only a temporary historical value and what has a permanent one for all time, we shall find that, in spite of differences of race and language, mankind is not only a unit in its mode of thought

its mode of thought, but has retained remembrances of modes of life lying far behind us, employing them on special occasions, as in memorial ceremonies or monuments. Objects become purely symbolical when their original purpose no longer exists, as in the case of the hammer and trowel in laying corner stones, a ship used as a table ornament or gift of honor; that uses become symbolical, like production of fire by rubbing together pieces of hard and soft wood, in the ceremonies of races that have long used flint, steel and tinder.

We therefore are still right in using stone ceilings for ideal purposes, even if the end could be more economically attained by other means, and the space could be vaulted, particularly in case of tombs, mausoleums, churches, and art-museums; such a use of stone beams is only possible when permitted by the narrowness of the apartment. But a second principle naturally follows; that stone-beam ceilings must not be imitated in wood or any other material, when the use of stone becomes impossible for statical or economical reasons. A false symbolism, like that introduced by the Neo-Grecians and never employed by a people artistically sound, consists in the external imitation of a thing, but a true symbolism can only result from the repeated use of similar means under similar material conditions. If we can use granite, its resistance to fracture being greater than that of marble, wider rooms may be covered by stone ceilings than those found in classic monuments; if we place light plates of glass or metal on these beams instead of heavy stone slabs, we can cover still wider spans. If a ceiling be constructed with wooden beams or iron girders, the interspaces would not be filled with marble slabs. Scarcely any course can then be taken that does not lead us to the forms of stone ceilings employed by the ancients.

The motive used in the construction of stone ceilings may be derived from the problem itself. If the space between two stone beams or walls is to be covered, the method first suggested is to cover it with a single stone, Fig. 106. To shed rain water, its top is inclined towards two or four sides, and as it is less easily broken when its weight is lessened, its under surface may be hollowed out. The largest ceiling stone ever yet used is that of the Tomb of Theodoric at Ravenna, which has the form of a low dome about 32.8 ft. diameter.

If the span be too great to be covered by a single stone, whether the supports are walls or stone beams, it is simplest to place several stones side by side, Fig. 107. The grandest use of this simple structural principle is in the Bridge of Loyang in China with 300 spans, each about 46 ft. clear; 7 beams of black marble reach from each pier to the next.

The problem may be

The problem may be solved in another way, according to whether the abutments are stable or not. If they are, the simplest mode would be to palce two stones against each other, or to arrange these stones in arched form, Fig. 108, with the condition that the stones shall not slip on the abutments. These and similar constructions of ceilings, employed by Egyptians, Etruscans, and Assyrians may be termed pre-classical. To them is allied the widely employed principle of corbelling out, u used in structures whose supports cannot resist a thrust. Beams of stone are laid to project inward beyond each other in an inverted pyramidal form, reducing the span until the opening at top can be spanned by a single stone, Fig. 109. This principle was always restricted to all ceilings of stone, where an increased height is not objectionable; its highest development in the stone broach spires of the Romanesque and Gothic styles, (also in Indian architecture).

The simplest form of corbelling is produced by a single projecting course on which is laid a covering slab, Fig. 110; in wider spans or for greater height of ceiling, several courses are necessary, projecting more in the first and less in the second case. Corbels may be formed in a great variety of ways either by partially or wholly bevelling them, Fig. 110, or may be treated as supports with convex profile forms occupying mo more space, or with transitional concave ones, or decorated by cymatiums and rounds, Fig. 111. Different nations employed in these corbelled ceilings simple bevelled corbellings, one or the other profile form, or a combination of members. According to the purpose and problem, these simple decorative expedients may be used now, provided that all the forms are generally acceptable, and result from the problem itself, none merely belonging to any special style. It is foolish to reject them merely because and particupal architectural style first employed or extensively used them.

Corbels as separate supports, Fig. 112, employed as modillions of cornices in classic architecture, or in the Middle Ages as supports for the most various purposes, are merely the smae mode of constructing ceilings in another form; for if the ceiling itself but slightly predominates in comparison with its support, the principle remains the same.

From the need of lessening the height of stone-beam ceilings constructed by corbelling, the classic coffered ceiling takes its rise. The architrave is the principal support of the ceiling and extends along the walls and above the columns, usually consisting of two deep beams placed side by side. The outer beams abutting against each other at the angles, while the inner beams are mitred together, Fig. 113. The stone beams form a gre

[illegible] showing large openin[illegible] the plan, [illegible] be [illegible]ered by any of the methods previously mentioned.
The classic coffered ceiling, Fig. 114, divides these large openings into smaller ones by a series of beams AA, and into a second series of still smaller panels by a second series of still thinner beams BB, then covering the interspaces by a number of slabs of stone hollowed-out in form of coffers to reduce their weight. The beams A and B together have a certain height corresponding to that of the geison or projecting part of the cornice, Figs. 114, 115, and it is so arranged that this is supported by B and also rests on the architrave, either by means of the triglyphs, as in the Doric, the interspaces between these being filled by metopes, or on the stone beam of the frieze, as in Ionic and Corinthian. In Ionic, the interspaces between the beams are sometimes materially lessened by corbelling out the beams A and B, a third series of beams C being sometimes inserted, upon which are laid the coffers.

With our knowledge of ancient architecture, we cannot assert the ceiling of stone slabs to have been developed to its full extent. Possible solutions of the problem were not used in classic styles, or have not remained to us. It is first to be considered that larger interspaces between stone beams may be covered with stone slabs laid agaist each other instead of coffers, Fig. 117; the slight thrust exerted by these may be neutralized by metal anchors. Further, the practice of corbelling may be employed in a more extended way than in the classic styles; finally, it is unnecessary to make coffers square, but they may as well be hexagonal or octagonal, when stones of suitable form are placed to support them, Fig. 118.

If the principle be consistently carried out, that the construction should supply the leading ideas for the architectural treatment, cassic beam-construction may be used now, the Ionic frieze as well as Doric triglyphs and metopes; but for the same reason, one should not regard the triglyphs as purely decorative expedients, as did Roman and Renaissance masters, and retain them when the frieze is composed of continuous blocks. Triglyphs are and remain supports, though perhaps originally used in another sense; metopes are panels, and neither has any justification for its existence, if it supports nothing or fills no interspace.

To declare the architrave unnecessary, when it does not span intervals between columns or piers but rests on continuous walls, like most Gothicists and Rigorists for false esthetic views, is no less a mistake and could only result from the erroneous idea, that the wall is merely to be considered as a space-enclosing member, and not a supporting one as well.

When the wall acts as a support, it must be regarded as a kind of continuous pillar. The masonry, even when most perfect, always requires a levelling course to support these parts above it, and the architrave is justly regarded as such a levelling course, when it does not span openings. This should more properly have triglyphs than the free-spanning architrave, whose centre should be as lightly loaded as possible, and the latter should be so constructed as to lessen the weight, as in Fig. 119, from Temple of Jupitor Stator at Rome. That classic styles employed the principle of corbelling in constructing the richer forms of ceilings is proved by the beautiful Tomb at Mylassa. The motive of this ceiling, Figs. 120, 121, exhibits a rich alternation of different forms of stone beams and cofrs

If we now consider the esthetic treatment of all these constructions, we shall scareely attain any result other than the classic, accepted by the Renaissance; beams are always bearers and connect supports with each other and the wall. To increas their resistance to transverse strain, their depth should exceed their width. Their lower surfaces are appropriately decorated by band-like patterns and imitations of twisted ropes, expressing connection; supporting moulded members are proper for their upper edges, which in the classic method are decorated by leaf-mouldings and beaded astragals. Their mouldings will have various profiles, according to the materials and the mode of lighting, the light almost wholly coming from below in case of ceilings, through windows and as reflections from the floor, when the coffers are not of glass.

The following distinctions in regard to the forms of ceiling are to be considered. If the moulding and the beam are a single piece, much material must be cut from the rough block. In constructing ceilings on a large scale, it is then preferable to insert the mouldings in the beams as separate pieces as at a, Fig. 122. If the principle of corbelling is to be utilized as much as possible, we should let the mouldings predominate as at b, Fig. 122, subordinating the vertical surface; according to the proposed end, the profile will be varied, either as taking the energetic convex or the softer transition concave form in lighter constructions. If the stone beams are all properly anchored together, or their ends are built into loaded masonry, when the architrave should not be too heavily loaded, and when the span is small and deep architraves of stone are not used, a strong projection of the corbelling is permissible; it is then best to mould the entire surface of the corbelled-out beams, since their centres of gravity are then set further back from their faces, as at a, Fig. 123, while with the arrangement b, the projection of the overhanging portion of the beam

of the beam makes it possible for it to tip over. If the beam a, Fig. 124, is so long as to have a firm support at each end, it may be corbelled out considerably; but the intermediate beams b, that complete the frame-work, must then either be corbelled out but little by the ends of the beams a a by inclined joints. The horizontal lower surfaces of these beams may likewise be ornamented by band-like patterns.

In mediaeval stone-beam ceilings, the angles of the beams are generally moulded by coves and rounds, Fig. 125; scarcely any objection can be made to this, yet all aproximations toward mediaeval forms should be avoided, the more the work is se removed from construction of churches, these forms becoming permissible in the degree the work approaches that purpose. A Renaissance that will satisfy all modern requirements, may very properly approximate more or less closely to any style-tendency, according to its needs, without losing its internal unity so long as it adheres to a principle generally applicable; but this principle is that nothing extraneous may be imitated, the form-treatment being developed from the problem itself, with which is always connected the purpose and the material, the construction, the external requirements of life, and the local conditions.

The vertical side surfaces of the stone beams are not usually decorated, yet they might be ornamented by a fret, the Grecian band-ornament, or by a band of palm ornaments.

The coffers themselves were stone slabs hollowed-out for greater lightness, and were treated in classic styles as if transparent, or as if one saw the starry sky through them, and were then ornamented by gold stars on a ground of blue or red. At a later era, these stars were changed into relief rosettes.

These decorative expedients for treating stone ceilings have a claim to be again employed, as both pleasing and characteristic, as well as venerable motives of form, consecrated by tradition. If it be desired to close the interspaces by several slabs joined together, rather than by coffers, Fig. 126, these should be made lighter by being hollowed-out, the joints being concealed by rounds or beaded astragals, and the whole being finished by a decorated keystone. The coffer might also be wrought from a thick block instead of a thin plate, hollowed-out and the surplus stone on its exterior being removed, then decorated by a suspended flower, Fig. 127.

Chapter 7. Wooden-Beam Ceilings.

These are either simple wooden ceilings, including ceilings of boards, or they are panelled ceilings. In both cases, the ceiling may be horizontal, or composed of horizontal and inclined planes

clined planes, or it may be curved.

1. The Simple Wooden-Beam Ceiling.

The simplest form of this is that composed of a series of beams upon which is nailed a flooring of boards, Fig. 128; if the floor be used or loaded, the beams must be sufficiently strong and close to support the load. If the span be too great fonubeams to dothis without bending, they are supported by girders at their centres, or by several at suitable ditances, Fig 129. These girders may in turn be supported by trussed beams and vertical posts, Fig. 130 showing several forms of trussed beams, used in mediaeval ceilings in Tubingen and vicinity. Figs. 131, 132 and 133 are other examples of similar modes of supporting beams by cap pieces, from Town Halls of Freiberg, Meissen, and the Germanic Museum,anat Nuremberg. These ceilings may be constructed with intermediate beams, Fig. 134, and the main beams may be doubled or trebled, instead of being supported by girders to support the load, and to prevent the board floors from being visible beneath, the interspaces may be filled with separate panels of boards.

It is now easy to deduce from the construction the motive that supplies the decoration. First consider the beams, their supports, lower and side surfaces, then their connection with girders, cap-pieces, trussed beams, the intermediate beams and doubled and trebled beams, also the board panels, their joints and enclosing mouldings, and grooved-in panels.

If the ceilings are not supported but are suspended from the roof construction, the suspension members and rods, the trussing of the beams with iron work are all to be mentioned. From the motive of the suspended ceiling may be derived peculiar forms, like those that were favorites during the Middle Ages, taking the form of vaults though built of wood. In all wooden construction, the supports of ends of beams are very important, for if the ends of the beams decay, the ceilg falls

These end supports vary according to the purpose of the work and its arrangement; either the ends form corbellings in wood and half-timbered walls that support the upper stories, Fig. 135 a, their ends are flush with the external surface, Fig. 135 b, they rest on the wall plate like beams of a wooden roof Fig. 135 c, their ends are built into the wall, Fig. 135 d, or tenoned into a wall beam according to a French method, Fig. 135 e; laid on a brick corbelled cornice, Fig. 135 f; a wall plate is inserted between the beams and the cornice, Fig. 135 g; corbels are used instead of a cornice, Fig. 135 h, with posts placed between the corbels and wall plate, with or without brackets, or finally, the wall plate rests on a projection

When the end-support of the beams forms an offset, so that

an interspace exists between the support and the board floor, this may be filled by a vertical board or one inclined forward Fig. 135 i; this board may be decorated by perforations and the joints between it and the board floor concealed by mouldings. The wall plates may be moulded, decorated by longitudinal stripes or left smooth.

The most pleasing forms of end-supports are derived from the motives f, g and h, when the cornices of stone or brick are of rich forms, or by developing the corbels. Very rich modes of constructing these supports were devised in the Middle Ages and Renaissance in numerous massive wooden ceilings of Dutch churches, Town and Castle Halls, etc.; the principle is to lessen the spans of the beams by cap-pieces. A corbel a supports a strut b, on which rest two cap-pieces c and d, that support the beam e. The cap c is supported by a brace i, a wall beam by braces h h, and serves to receive the board floor laid on the beams. The corbels are formed like classic consoles, or decorated by shields, heads, or figure sculptures; the cap-pieces may be characterized in very varied ways, being both free ending and supporting members, for which the volute curve derived from the Ionic capital supplies a suitable motive; struts are generally cut from crooked timbers and are curved in various ways; finally, the struts and beams are moulded or otherwise decorated; massive wooden pins with carved ends, in proper places, increase the pleasing appearance of such ceilings.

An example of a beautifully carved cap-piece is given in Fig 137, from Burghausen. The interspaces between beams e and f may be filled with perforated, carved or smooth boards.

The lower surfaces of the beams are appropriately decorated by band-like patterns of carving or painting and the sides by frets, bands of palm ornaments, etc., borrowed from stone beam ceilings. But the most suitable method is to mould the angles and surfaces of the beams; as these mouldings are produced by planes, they either extend the entire length or stop against special carved ornaments at the centre and ends. A fine example of low rise, from Zurich is shown in Fig. 138. Girders are to be treated like beams. For trussed beams, four examples of which are given from Tubingen, the form of an elastic spring may usually be recommended, as seen in the bow, and in the allied form of the Ionic capital, because its nature and function fully corresponds to that of the trussed girder.

For intermediate beams, these being less heavily loaded than main beams, they should express the character of this loading. Whether main or intermediate, the chief idea of the moulded beam is that of being a bundle of pieces, bound together and firmly resisting the bending of the beam; rounds, coves, fillets

lets and grooves, as well as chamfers, alternate with each other in rich variety. In this way are produced the mouldings of double or treble beams by combining the half sections of the separate beams of the different layers. Figs. 139 and 140 are examples for ceilings and beam sections from Castle Chillon; Figs. 141 and 142 are from the Castle of Meissen; Fig. 143 is from Castle Schaerenburg near Dresden; Fig. 144 from Nicolai Chapel near Dresden, the two last being in Renaissance style.

The rules already given apply to board panels; joints may be tongued and grooved, or rebated and beaded, so that no crack appears after shrinkage of the boards. The joints may also be covered by strips fastened by one edge only, that the adjacent board may freely expand and contract.

Inserted panels should be enclosed by mouldings and may be left plain, carved or perforated. The esthetic effect of such ceilings may be materially heightened by partial painting and gilding, and if necessary, a pleasing effect can be had by using white, black, yellow ochre and Indian red. But in ceilings with moulded beams, similar members must have the same color, gold should only be used for fine lines, and the members should be sharply separated by narrow fillets and grooves, etc., that the colors may be used on spaces moderately lighted. The further the ceiling from the eye and the less strongly the room is lighted, the brighter must be the colors, so as to give a good general effect. For the same reasons, painting objects in bright and gay colors may be censured, as in furniture of churches, when to be viewed from a short distance, an error in taste that has recently become quite fashionable with many architects.

Different decorative forms result from the construction of suspended ceilings, where the intersections of beams require special consideration. If suspension members are iron rods with screw ends and nuts, a washer must be inserted between the nut and beam. This washer may take the form of a rich iron ornament, it may be replaced by several iron disks placed on each other, or by suspended chandelier-like ornaments. The last are especially appropriate with suspended chandeliers.

We have already stated that trussed constructions may be employed to divide the ceiling in vault-like portions; suspension rods then end in drops or suspended knobs, and the ceiling may be composed of groined vaults with ribs and arches, on which the covering of boards is placed, their apexes being ornamented by carved wooden bosses at intersections of ribs. In Belgium and Holland, very graceful ceilings of this kind were built until the Renaissance, as in Harlem, Fig. 145, the coverings being made of boards bent by steaming. the richest Gothic

vaulted constructions being imitated, though treated in a manner perfectly adapted to wood construction.

Transferring this structural principle to horizontal roof trusses leads to tunnel vaulted ceilings, Fig. 148, very frequently used in Dutch buildings, and either covered with board or, as natural to a peaople engaged in shipbuilding, treated like ship-framed ceilings in form of groined vaults; if all timbers are suitably moulded, and posts, struct and the free-ending posts are properly carved, these ceilings are very pleasing. The horizontal beams, that support the entire construction, were decorated by painting, and were generally utilized in churches to form a platform, so that one could walk the entire length of the church on the ceiling.

Beam ceilings also require mention, whose interspaces are not covered by boards but by burnt tiles. This mode of construction, hitherto only used for stables, is evidently capable of esthetic development, and may be used for other purposes; this is also true of ceilings composed of wooden beams set diagonally with brick arches turned between them. Instead of tiles, plates of stone, cement, slate, glass, etc. might be used, according to the purpose of the ceiling. Board ceilings are wooden-beam ceilings covered on the under side with boards Their decoration consists in painting, and in covering their joints with moulded battens, or division into a few large panels, each panel being enclosed by boards partly perforated, partly carved, as in a church at Zug, Switzerland.

2. Panelled Ceilings.

Many of the wooden-beam ceilings just described might also be termed panelled ceilings, though true panelled ceilings were introduced by the Renaissance, and began as imitations of classic coffered ceilings, developing into forms quite different from those of beam ceilings. They are composed of intersecting beams, all those of large ceilings being either halved together at the intersections, that are also strentghened by bolts or keys, or some beams extend through, the other beams abutting against or tenoned into them. Since wooden beams of great length may be obtained, the web-system may be used as a basis for coffered ceilings. One produced by intersections at 60 deg. is given by Serlio. Large coffered ceilings appear somewhat monotonous; Renaissance masters sought to avoid this by replacing a group of coffers by a larger panel, that might be square, oblong, or cross-shaped.

New motives for ceilings are produced by dividing the larger panels into smaller ones by smaller beams, also by changing square into octagonal panels by cutting off angles and thereby strengthening the corners, or into cross-shaped panels by small

small beams placed at right angles; lastly, by producing ends of smaller beams beyond intersections with larger ones. Compare the motives represented in Fig. 147.

A further improvement in this mode of constructing ceilings can be made by small beams set diagonally, Fig. 148, by tenoning the ends of small beams into the frames of separate panels b, and by the introduction of circular forms, or those of other curvatures. These ceilings may be further decorated by using beams that do not intersect, but are merely tenoned together, Fig. 149. With these expedients, we can obtain an infinite variety of possible arrangements of ceilings, that are all derived from simple coffered ceilings.

Many of these constructions are not very strong, and if required on account of their pleasing appearance, a series of beams is laid above the ceiling, to which this is fastened by bolts. At the points of intersection of the ceiling it is to be bolted to the beams, the bolts being variously decorated by knobs, rosettes, etc. All divisions of surfaces composed exclusively of curved forms may thus be employed for panelled ceilings. As in beam ceilings, larger and smaller beams may be used in panelled ceilings also.

Motives used in decorating panelled ceilings are essentially like those used in panel-work, stone and wooden-beam ceilings. But it must not be forgotten that these, like all toher forms of ceilings, must possess a distinctive character, corresponding to the material, and that decoration by carving, gilding, and color are especially appropriate.

Lighter horizontal lattices may be bolted to beam-ceilings, their interspaces filled with boards, producing boarded or battened ceilings, subject to the same rules as lattice-work.

Chapter 8. Iron Ceilings.

Iron ceilings are partly used for safety against fire, partly because that with the aid of this material, the widest room may be covered with greatest economy of material and cost. Besides iron, only stone and brick are used for fireproof ceilings, wood being used for those not fireproof.

Iron ceilings are usually constructed of iron beams or girders, supported by separate trusses for wide spans. Girders of cast and wrought iron require simple forms, and lattice girders take special forms with the least propriety; forms of uniform strength are approximately used for iron construction, and oil painting is required to protect the iron from rust, also materially enhancing the pleasing effect of iron construction.

Iron ceilings are preferably employed for buildings intended only for ordinary purposes, making a minimum of artistic treatment

ment usually sufficient if the general arrangement be pleasing and the pleasing effect increases with the simplicity and clearness of the construction. In iron construction, the volumes or rather the magnitudes seen by the eye are small in proportion to the wide rooms covered; the external appearance of iron construction depends less on the forms of the individual structural elements, than on the modes of their connection and arrangement. In iron ceilings not too far removed from the eye, the iron beams should be decorated by elegant mouldings or perforated ornaments if of cast iron; but wrought iron girders being made of rolled plates riveted together, can have scarcely any form other than that absolutely required by their purpose.

If the interspaces between the beams are vaulted, the same rules apply, that are given in treating of Vaults; if filled with slabs of stone or wooden boards, their panels are to be treated like those of stone or wooden ceilings. If glass be used for this purpose, it can be decorated by etching, engraving, or true glass staining may be employed.

Chapter 9. Visible Trussed Roofs of Iron and Wood.

These are ceilings supported by a combined and mutually st strained system of connected members, which consist of vertical supports, inclined braces and struts, horizontal ties and tie-rods, with horizontal tie-beams connecting the two end joints. If the supporting members are placed above the ceiling, this becomes a suspended beam, corfer, or panelled ceiling, and principlas given for those ceilings become applicable The roof covering of visible trussed wooden roofs is not supported by beams, but by rafters, and these may directly support the roof, or purlines may be interposed between the roof and principal rafters; rafters are usually straight, rarely curved as in Barocco spires. The supporting system of a series of rafters is termed a truss or roof-truss.

1. Wooden Trussed Roofs.

For covering these roofs, the motives of form result from ideas already given for.. treatment of ceilings. The covering material, stone, tiles, glass, slates, wood, straw, metal, etc is usually fastened to a series of strips of wood, that may usually be decorated like other strips or bands, according to their nature and purpose, if the covering remains visible, like panels in interspaces. The supporting rafters, whether straight or curved, from their small resistance to bending, should have greater depth than width like all toher beams, and should be treated as beams. If the rafters supporting the purlines are composed of curved pieces, they may be decorated by carving, according to circumstances

by carving, according to circumstances. We may employ for filling interspaces between constructive members, perforated or solid panels of all kinds, also using carving, painting, and gilding, on suitable prominent parts of the structure, metallic ornaments, etc.

Simple and clear construction is always the most important thing in all trussed roofs of iron or wood; abrupt transitions in the directions of different intersecting structural parts may be softened by transitional curves in rare cases, almost entirely limited to massive roof and bridge construction of rolled plates; it is necessary to avoid such interventions, opposed to a rigidsystem of massive construction, when construction and energy of effect do not require for esthetic reasons any softening or weakening. ofOnly in case of rafters of many trusses of wide span, intersecting at oblique angles, is it often proper to insert large transitional curves, that lend a bold sweep to such roof constructions; such structures are quite justifiable for roofs of railway stations, halls, etc.

2. Iron Trussed Roofs.

The treatment of iron trussed roofs is similar in principle to those constructed of wood, the difference in the two resulting from the essential difference in the two materials, and the technical processes dependent thereon. Economy of material and weight with the greater strength of iron members of equal section, compared with those of any other material, gives to iron construction a lighter character throughout than that of any other construction. The peculiarities of the modes of connecting the different parts, mostly joined by bolts, rivets, screws, and wedges, opposes a free movement in the artistic form of iron trussed roofs, a freer play being almost entirely limited to parts composed of cast iron. But what is lost in richness of form by rigidity and thinness of the iron construction, as well as by the difficulty of working the material, can be somewhat compensated by the use of plates of cast iron, perforated or decorated in relief, by decorations in thin metal, by decorative details in wrought iron, and lastly by oil painting, necessary as a protcetion against rain, and by gilding; further, since iron construction is never required to possess the predominating monumental character of stone construction, but always subserves a purpose more or less temporary, a moderate use of zinc is not excluded, being an auxiliary material par excellence of our time.

Chapter 10. Vaults.

The vaults preferably employed in architecture may be arranged in three classes, briefly described here; 1, Classic; 2, Mediaeval; 3, Renaissance vaults.

Classical vaults include tunnel vaults, domes, and groined vaults without ribs produced by the intersection of tunnel vaults. The name mediaeval is applied to all ribbed vaults derived from classical forms. Renaissance vaults include all modern forms existing since the beginning of the Renaissance, unknown to either the Classic period or Moddle Ages; welsh-groined vaults, with or without intersections by tunnel vaults conical vaults of curved outline, only constructed with ribbed vaults during the middle ages, etc. We shall neither treat the historical development of the vault, nor describe all the structural peculiarities of vaulted construction, required in a treatise on mediaeval architecture or building construction, therefore touching on the historical but slightly, as hitherto and on the structural only as far as may be necessary to deduce the decorative treatment of the vault.

1. Classical Vaults.

Roman vaults, as well known, were either built of voussoirs or of hollow pots, stuck into each other, or of separate principal arches connected by intermediate arches, the interspaces between these two kinds of arches being filled with concrete. In most cases, the surfaces of the vaults were coated with plaster, since the excellent bricks and cement made unplastered stone vaults entirely unnecessary, or limited them to the smaller structures.

a. Tunnel Vaults.

If a series of arches are placed side by side, the simplest form of the tunnel vault is produced; if the voussoirs are of stone, the motive of hollowing-out their under surfaces result from the requirement that the stones must be as light as/possible, to lessen the horizontal thrust of the vault. This hollowing-out is best fulfilled by the formation of a rosette, strongly projecting from the sunken back-ground, thus producing a coffered ceiling from the vault in the simplest way, and quite independently from the horizontal stone ceiling.

The idea of the tunnel vault with coffers once accepted, a slight consideration leads to further progress; the end joints of the vaussoirs appear too prominently on the inner surface of the vault; they are concealed by decoration with sunken mouldings or beaded astragals. But the vault may be more tastefully constructed of supporting arches, each stable by itself, the arches joined by longitudinal connections moulded like the arches or otherwise, then filling the interspaces between the two systems by separate

tween the two systems by separate slabs of stone. Coffered vaults are thus produced, similar in external appearance and allied in principle to coffered ceilings, since the supporting parts form a complete system by themselves, and only thin slabs of stone are required for filling the interspaces. Perhaps the most beautiful vaults constructed on this plan, thou though in a developed form, are those of the sacristy of St. Spirito at Florence, and another specimen is given by Viollet-le-Duc, in which the intersections of the transverse arches ad and the longitudinal members are marked by bosses.

If the vaoussoirs are small and of soft material, like tufa, or are artificially made, like bricks, they may be arranged in web, embroidery or mosaic systems, which has only been exceptionally done in decorative work. Strack used vaults of this kind in the graceful vestibules of Bersig's Shops at Berlin. The unders surfaces may be decorated by pressure in suitable moulds, or soft materials like tufa may have carved, raised or sunken forms.

Semicircular and pointed tunnel vaults, when 1-2 brick thick are entirely composed of stretchers parallel to their axes, while Dutch bond is employed for thicker vaults. Such vaults are most simply decorated by borders and by making their upper portion prominent by means of colored bricks, also by the use of decorative bonds, that may always be used in tunnel vaults.

Smaller tunnel vaults of low rise are most tasteful if vaulted parallel to their diagonals, as Fig. 150, a or b. The middle of the vault is then marked by the intersections of the bricks, and to decorate the construction by colored bricks is appropriate for the middle and edges of the vault.

If long rooms are covered by tunnel vaults, these are divided into bays by transverse projecting arches, partly to break the monotony of the vault and obtain greater variety, partly to make the vault lighter.

A mode of constructing tunnel vaults by a series of strong brick arches connected together by longitudinal arches, the interspaces being then filled with concrete, again leads to the coffered vault, is a method of construction frequently employed by the Romans, and is fully explained by Viollet-Le-Duc.

2. Roman Groined Vaults.

Groined vaults on the Roman system, produced by the intersection of two tunnel vaults, the diagonal arches not projecting beyond their surfaces as groin-ribs, are to be treated like tunnel vaults. In stone vaults, the curves of intersection being elliptical, the individual stones of the diagonal arches take peculiar forms, and each must be worked out separately, so that the tunnel vaults may unite in a good bond. Since the tunnel

tunnel vaults rest on these diagonal arches by means of the indentations of the bond and heavily load them, their depth must either be greater than that of the vault, or they must be of a stronger material than the vault, so as not to be crushed under the load. This strengthening of the diagonal arches then expresses their greater importance than the surfaces of the vaults, either by a material of different color, by a special mode of decoration, or by greater prominence of the lines of intersection of the vaults in form of ribs wrought on the stones of the groin arches to strengthen them. The inconvenience of determining and working these groin voussoirs with their complicated joints, naturally leads to the idea of strengthening the groins by constructing the groin ribs as if independent then letting the surfaces of the vaults intersect above them.

The plan of a Roman tunnel vault with longitudinal and transverse arches, but without special projecting ribs, was arranged as in Fig. 151, a; that of a vault with groin ribs as at Fig 152, b, when care had been previously taken to provide complete support for all arches of the vault by arranging supporting piers on the plan. But not only the latter was required, but the cutting of the springing joints of the arches was to be simplified, and a perfectly free development of all spearate arches of the vault was to be attained, then the piers Fig. 152 c required the addition of a projecting diagonal member.

The ribbed vault was thus derived form the construction of the Roman groined vault in accordance with requirements of expediency; if the ribs are to be entirely omitted, and the vault is so well built or its loading proportionally so light, that they may be omitted, then Fig. 151 a becomes the plan for the normal arrangement of groined vaults. The Renaissance closely followed Roman architecture, and absolutely preferred the groined vault without ribs to the mediaeval ribbed vault.

c. Roman Domes.

The dome is bounded by spherical surfaces, all sections containing the vertical axis and vertex being great circles. For structural and decorative reasons, we must distinguish between simple domes or hemispheres, half domes over niches or quarter spheres, and pendentive domes constructed on square, polygonal or triangular plans.

The simplest mode of constructing domes is to compose them of horizontal rings of voussoirs, all bed and end joints radiating from centre of the dome; each voussoir then has two radial beds and two vertical end joints. The apex is formed by a conical keystone, its under surface concave and spherical. If such a dome be built of cut stone, it can be made a coffer dome by applying the principles already found to govern stone

tunnel vaults. If constructed of brick, block and heading bonds being generally used for structural and economical reasons, though ornamental bonds are not to be excluded from slamm domes, the decorative motives produced by these bonds afford abundant means for the decorative treatment of the surface of the dome; the bordering forms at the base of the dome, its apex, the courses in horizontal rings, the vertical and oblique directions of the brick bonds, furnish suggestions for the entire decoration.

The dome may also be considered as divided into sections by meridians, diminishing toward the vertex, and may be composed of voussoirs having thinned edges toward the apex; this unpractical method of construction should be regarded as fanciful, though a great favorite in the late Dutch Renaissance for niches and small domes.

A combination of the two methods of construction is found in coffered domes in Roman and Renaissance architecture, carried out on the largest scale in the Pantheon at Rome. A series of vertical arches, diminishing toward the vertex by offsets, form great circles of the dome and are connected together by transverse arches, the interspaces being filled by coffers. A refinement was first used in this dome, which had a pernicious effect in later times and led Renaissance masters into error; the side surfaces of the coffers all radiated from a centre in the axis of the dome, so that instead of a natural perspective fore-shortening of the coffers, a perspective architecture was introduced, that only appeared in some degree correct from the centre in the axis of the dome, but had a distorted effect from any other point; the side surfaces entirely disappeared from view at this centre. For our modern era to commend this theatrical effect as an ingenious idea, as often happens, can scarcely be termed other than an error of judgement of the esthetic faculty. The lower edges of the coffers only should be inclined downward so as to be entirely visible, but not the others.

A peculiar form of domes is obtained by constructing it of horizontal rings, also with sections diminishing toward the vertex, if the vault is executed in herring-bone bond, as in the dome of Florence Cathedral. This produces a pleasing arrangement, which may be decorated in various ways by using colored stones. According to an allied principle, a dome may be conceived as being formed of separate spherical triangles or rhombuses, their sides partly forming great circles, partly spherical spirals on the surface of the dome terminating at the apex, a mode of construction never yet executed, though allied to many late Cothic star vaults.

On the paln of any dome may be drawn a regular system of straight lines, to be regarded as the horizontal projections of a system of circular arcs lying on the surface of the dome. The compartments of such a dome may be filled with brick masonry regularly arranged in any fixed direction. We find two very strong domes on the Temple of Jupiter at Spalato and the Temple of Minerva Medica at Rome; the former consists of a horizontal series of arches turned above each other, the inter spaces being filled with concrete; the other is composed of doubly curved vaults turned between meridian arches, so that the dome is musk-melon shaped. Strictly speaking, mediaeval ribbed vaults of all kinds are merely regular combinations of systems of ribs, whose interspaces are filled by similar vault of double curvature, partly spherical-ellipsoidal, partly horn shaped ellipsoidal surfaces, like those of the melon-vault. Fig. 153.

Domes constructed of pots, employed not only by the Romans, but also by many modern architects, for covering wide rooms with the least weight, hardly require consideration, as they are almost always covered with plaster. If their construction is to remain visible, the bottoms of the pots placed toward ts the centre of the dome, and the joints be filled withmmortar, cement or plaster, which might be painted or gilded, while the bottoms of the pots could have stamped ornaments.

The half-domes of niches are chiefly distinguished from domes in construction and decorative treatment by the fact, that usually not their vertices but some point on their lowest edge furthest from the eye, is to be regarded as their pole, so that the axis of the dome is horizontal. If the half dome is to abut agains a whole dome to resist its thrust, as in many buildings on the Greek cross plan, or terminates a tunnel vault, it should be constructed as a half dome with vertical axis, and be decoratively treated accordingly, while domes over niches were usually from the earliest times treated in shell-like forms, similar to a muscle shell, thence termed Concha. The concave, attractive and inviting character of the niche, leading the eye to the pole of the half dome or shell, that point of the construction to which the eye feels restricted, and from which the energy of the whole seems to radiate. Similar ideas led almost all nations to decorate the concha with radiating forms, as if pencils of rays radiated from the pole in all directions, as seen in the sky when the sun sinks below the horizon. Hence, in churches, the pole of the niche is usually decorated by a representation of the head of a Divine Being or a symbol representing this. Roman and Renaissanc architects generally preferred to decorate the concha s of

small niches with shells, especially those of fountains and cascades.

During the late Renaissance in Holland, it was a favorite idea to construct domes of niches with radiating voussoirs diminishing towards the pole; this was carried so far as to cut bricks to form the intersections at the pole, while the radiating lines of the brick bond were but 1-4 brick apart at the outer edge of the niche.

All whole domes and domes over niches may be termed umbrella domes if their vertical axes be accented, whether actually divided in sections by great circles, or meridians and zones are only indicated, as in church domes sprinkled with stars or decorated by soaring angels, etc.; all those niche domes may be termed shell domes, where the pole on lower edge is treated as the principal point; to decorate a full dome by accenting any axis other than the vertical would be erroneous, and the same would be true of a niche dome, whose top and rear are left plain, while its sides are made prominent.

Pendentive domes are produced by constructing a polygon of any form, whose angles lie in a circle or ellipse. This is usually a regular polygon of 3, 4 , 5 , 6, 8, etc., sides. All pendentive domes are partly directly supported by the piers a, b, c, d, if square, the remainder resting on the arches a c, c b, b d, da, erected above the sides of the polygon. The radius of the dome equals the radius of the circumscribed circle of the polygon, therefore equalling the half diagonal of a regular polygon. If a plane be passed through the vertices of the arches, which have equal heights in case of regular polygons, this separates the pendentive dome into an upper calotte and as many pendentives as the polygon has sides. The plan of the calotte is identical with the circle inscribed within the polygon.

The pendentive dome should always be decorated from another point of view than the dome; besides its vertex, it has n lowest and n characteristic points, corresponding to the centres of the arches, which require esthetic prominence; they are usually constructed by making the courses horizontal and corbelling them out diagonally in the pendentives up to the base of the calotte, which is alone constructed as a dome. The decoration then naturally has reference to the characteristic points, or if the calotte be constructed independently from the pendentive, which is perfectly proper when these are built in horizontal courses, the charteteristic points are not made prominent on the calotte, or are merely indicated. The borders and the accenting of the vertex by a keystone will be decisive in both cases, and the indication of diagonal lines in

the first case, and the development of the pendentives in the second, will be equally so. The pendentives gradually increas in width upwards from the piers, and afford opportunity for the introduction of polygonal or circular medallions; they may be so decorated that the ornament is gradually developed from the lowest part of the calotte. The calotte should be separated from the pendentives by a border or a cornice. Most domes require a keystone to complete the vault.

The smaller the rise of a vault, the less the load that it may safely support, by conditions of its stability, and the greater its rise, as in case of a pointed arch, an elliptical arch with vertical major axis, a parabolic or catenary arch, the greater the load that may be placed upon it, and also the greater is the weight required to be placed on its apex to insure its stability.

Further, the completion of a dome is always technically difficult in vaults of great span, and an opening is commonly required at the vertex for the admission of light, or for hoisting building materials, etc. From these points of view, the following rules for special cases are derived; segmental and semicircular domes of small span are not properly finished with a keystone, which in very small domes should be so formed as to exert no thrust. If the diameter of the dome exceeds a certain value, instead of a keystone, a complete stone ring is preferable, the centre remaining open for admission of light, etc., and can finally be filled with a more or less flat stone

Stilted or raised domes, whose rise exceeds their radius, must be loaded in a peculiar way, and therefore require massiv keystones, that may be bold, suspended rosettes in full domes, or should be a circle of heavy voussoirs in domes open at the top. In very large domes, like that of the Pantheon at Rome, the Cathedral at Florence, the Church of St. Peter at Rome, the Church of St. Genevieve at Paris or of St. Paul in London, the upper circle of voussoirs permits and requires an unusual load which may take the form of a special lantern placed thereon; in some cases, three domes are placed above each other, the lower or ture dome having an opening at its centre, the second being steeper and supporting the lantern, while the third is the external covering dome, whose weight, with that of the second dome, combines with the horizontal thrust of the first dome as a vertical pressure. The upper ring of the inner dome may then support a gallery, and may be connected by a colonnade with the upper closing ring of the second dome that supports the lantern; but this colonnade should not cause too great a load on the lower dome, nor should it support the closing ring of the second dome, since in both cases, the lower

dome would be in danger of falling, and the second dome would be useless.

The closing rings and keystones of domes, being their highest and most prominent structural parts, give opportunity for particularly rich treatment; in lightly constructed domes of low rise, the requirement that the crown of the dome should be as lightly loaded as possible, demands the use of hollowed-out vaoussoirs in the closing ring, that then more or less closely approximates the form of the edges of a flat dish, while strong domes require loading and need to have their deep crowns loaded with as much weight of decorations as possible.

Pendentive domes permit the construction of hemispherical or stilted domes in place of a calotte, above the cornice that terminates the pendentives, a mode of construction especially peculiar to Byzantine architecture, retained in the French Romanesque style, and justifiable in many cases.

2. Mediaeval Vaults.

These are ribbed vaults based on the groined vault, tunnel vault, and the dome, but whose compartments between the ribs are constructed as portions of domes. Cloister vaults also require mention in addition to these.

a. Mediaeval Groined Vaults.

We have followed out the structural principle of the Roman groined vault so far as developed without becoming untrue to its character, always based on the intersection of two tunnel vaults. The elliptical forms of the groin ribs caused inconveniences in stone cutting, varying for each separate stone. The mediaeval groined vault sought to free itself from all th inconveniences of the Roman groined vault, and made the groin ribs semicircles. This arrangement is attended by the consequences more or less troublesome; if the side arches are semicircular, their crowns are lower than those of the groin ribs by the difference of the half diagonal and half side; the vault must then rise from the side-arches to the crown, unless we are willing to raise the crowns of these arches to the same height as that of the vault, either by making their abutments of two different heights, which produces a very awkward treatment of the capitals, or by stilting the side arches, which is not very pleasing. The inconveniences are increased when rectangular bays are to be covered by groined vaults, and both side and groin arches are to be semicircular; we must then have different heights of crowns or of springings, or stilt both kinds of side arches.

The use of the elliptical arch for diagonal ribs may be avoided by substituting for it an oval arch, and if this be struck from as many centres as possible, it is hardly inferior in its effect

effect; if the groin ribs are semicircular, the side arches require to be stilted by about 1-8 their radius, as the abacus of the impost moulding of the pier would otherwise conceal the lower ends of the arches, which looks worse in arches of small than of wide span, with equal projection of the abacus; but for the vault to rise from tops of side arches to itscrown is not ugly, but even preferable for esthetic reasons, if the les ser illumination of the crown be neglected. Such vaults do not convey the idea of pressure, but that of a free sweep, and an increase in the height of their crowns corresponds to an in crease of span. In low rooms, retaining the same height of crown and side arches, we can use the expedient of placing the springings of the groin arches below those of the side areches or the segmental arch may be used.

As for the introduction of springings at these different heights, and correspondingly varied capitals, this arrangement is certainly richest and most pleasing of all possible methods for its variety; the most consistent structurally, but also the most expensive; to be willing to sacrifice this in monumental structures because the end may be more simply attained, as unfortunately done in the more perfect Gothic, is to exchange one of the finest expedients for poverty of ideas. If th the exteeme means allowable in Art are to be employed in excep tional cases, where everything normal appears trivial, the higher cost should not then be feared.

In case of lean construction or mean proportions of the room to be vaulted, a moderate stilting of the arches, as well as a moderate raising of the crown of the vault, is best suited to produce the most pleasing effect. In quite oblong groined vaults, the heights of the crowns of the arches on the longer sides and of the groin arches approximate each other somewhat, but the other end arches require to be stilted considerably.

The early Gothic employed pointed arches at the sides, so as to obtain control of the heights of their crowns and not be compelled to use the circular arch, which was only used for the groin arches. The choice then existed of constructing all the side arches with the same radius as that of the groin arches, and which is practically preferable, as all voussoirs can then be wrought by the same template, special springing and keystones only being required, the crowns of the arches not then being at equal heights; or the heights of the arches are arranged at pleasure, making the pointed arches dependent on these, which may then be made equilateral pointed arches, requiring to be stilted, or so that the narrower side arches are lancet arches, all having a common springing plane. It is always most judicious to use a single radius for all the arch-

es, to allow the crown to rise gradually, and to stilt the arches about 1-8 their height. To make the groin arches themselves pointed is quite useless, if the vault be not very heavily loaded.

The pointed arch is to be preferred over the circular arch for the side arches, because with a moderate difference from the round arch, it is more piquant, aspiring and dignified. If we once become accustomed to not always see the Gothic style when the pointed arch is used, it may be used in Renaissance as well, whenever appropriate. It was no more rejected in early Renaissance than was the circular arch in Gothic, neither rejecting anything practically usable for blind subjection to principle.

The separate compartments between the ribs were always so covered in mediaeval vaults as to make their highest line curved, therefore becoming portions of domes. Two modes of vaulting were is use, the vaults either being constructed after the classic method of building tunnel vaults, by courses at right angles to the axis of the tunnel vault, or in later times diagonally, so that the half side arch, transferred to the diagonal arch, gave the point to be connected with the crown of the side arch. The other points of the diagonal arch were connected with the corresponding points of the middle curved line of that compartment of the vault. The separate portions of the vault very heavily loaded the groin arches in the first case; but they intersected above the ribs in the second, so that this bonding together was in itself quite strong, the ribs proper had but little to support, and as stone coverings rather served to relieve the vaulting.

If the vault exceeds the normal width of smaller bays, which first happened in vaults over intersections beneath towers of the larger French cathedrals, there were two modes of dividing the groined vault into smaller compartments; either divided on plan into 8 equal smaller compartments, forming octapartite groined vaults; the inconveniences of springings of unequal height, of unequal heights of crowns, of stilting, or the use of different forms of arches, were increased, for a d and b d, Fig. 154, become semicircles and a c and c d are different quadrants if pointed arches are not used; but with pointed arches, the groin ribs a c and b c are quadrants, c d and c e are half-pointed arches, while a d and b d are either semicircular or entire pointed arches; the problem may also be solved by using segmental arches, without introducing too many unpractical results. Or the groined vault may be divided into smaller compartments by subdividing each of the four original compartments in three, producing the following results. Fig. 155 and 1

ad plus c d is greater than a c; if the crown of the vault is to be highest, which is not absolutely necessary, as the crown of the side arches may be higher than that of the vault, the radius of the longest arch, as a d plus c d, is to be taken as the basis of the construction of the vault; this was termed the 'principal arch' in the later Middle Ages.

A few considerations, with observations of actual structures will place the various difficulties in a true light, that result from construction of groined vaults in accordance with mediaeval principles. If sections of all vault ribs and side arches are similar, or those of side arches are composed of sections of one rib and two half ribs, it will always be preferablbleto employ a single radius for all ribs and side arches to simplify the construction. One then has a choice of using segmental or pointed arches in addition to the semicircular arch of the groin rib. The form of the segmental arch is generally associated with the idea of the Secular, of the absolutely esesntial at the expense of beauty, and of the Common, while to the pointed arch is joined the idea of the Ecclesiastical or Monkish, not agreeable to all. If the segmental arches are neither principal ribs nor side arches, but merely intermediat ribs, they are pleasing in contrast with circular or pointed arches, as their oblique springing from the vertical gives a piquant effect to the vault.

To adopt the exclusive use of circular arches would often result in the greatest amount of labor, with an esthetic effect affording very little pleasure; high stilted arches appear well only exceptionally, and a strong curvature, that detaches small circular arches from their tangents, is very disadvantageous. To discover the best relation between the amount of labor and a pleasing result in a special problem frequently requires many trials before a decision.

The two examples of the division of the groined vault into several compartments include all complex varieties of multapartite and ornamental groined vaults. Multapartite vaults may be constructed on any polygon, heights of side arches may be assumed as required, as well as that of the vault, since the crowns of the arches may be arranged to bring the springing points high above those of the groin ribs, as often necessary in vaults of towers, or required for free transmission of light, and to avoid transmission of horizontal thrust of compartments to side walls, the vault then rising considerably from its keystone to crowns of side arches.

b. Mediaeval Groined Vaults.

Simple mediaeval domes are constructed differently from Roman; but the dome was usually not much liked. Ornamental domical

cal vaults of the late Middle Ages, which we have already considered star vaults, are preferably employed for covering polygonal rooms; all intersections of the ribs lie in the surface of a sphere, whose radius is that of the inscribed circle. The compartments are covered as spherical surfaces of small curvature.

Since compartments of both groined and spherical vaults are stronger, the more they are curved in cross section, they are sometimes curved so much in strong vaults, that their highest point is considerably above the crown of the vault, Fig. 161. Such "full-breasted" vaults appear more animated than flatter ones, because affording a richer contrast of light and shade. They are therefore to be preferred if not painted; but if painted, the flatter are preferable.

c. Mediaeval Tunnel Vaults.

The simple mediaeval tunnel vault without ribs differs as little from the Roman as the simple dome, but the ornamental tunnel vault differs in very essential points. The ornamental tunnel vault of semicircular section is most simply formed by making its half span a c, Fig. 162, equal to the height c c'. This construction is suitable for elliptical vaults required for low rooms. If these are very low, requiring a rise less than the half span, we may take a segmental Tudor arch as a principal arch as in the Netherlandish-English system. Still, the most natural mode of constructing the ornamental tunnel vault will be to take the diagonal arch a b c b a, Fig. 163, as the principal arch, making it a semicircle; all ribs then have the same radius, and all intersections lie on the surface of an elliptical vault, whose major axis is vertical. Fig. 164

In larger rooms, a second system of ribs is inserted between those of the first system, Fig. 165, and constructed on the same principles. Ribs can also be struck to the side walls as segmental arches, whose springing points lie above the general springing lines; the vault may be further ornamented in various ways. These ornamental vaults of all kinds are intimately related to Roman coffered vaults, from which they essentially differ in having vaulted compartments instead of coffers. The ribs are unnecessary in vaulting at right angles to the axis of the compartments, the brick bond of the compartment forming a species of stiffening rib along the intersecting edges, that does not project below the surface of the vault.

Late Gothic sometimes employed ornamental vaults without rib ribs, their compartments being formed as sunken pyramids with curved surfaces, thus being vaulted as cloister vaults with curved inner surfaces, Fig. 166, especially in Saxony. Such vaults, essentially belonging to brick construction, deserve

imitation in purely structural buildings, and when it is desired to produce a rich effect with small means.

d. Decorative Motives of Mediaeval Ribbed Vaults.

The decorative elements, that decide the external appearance of the mediaeval vault, are the ribs, their geometrical arrangement, proportions of their dimensions to those of the compartments, their profiles, keystones, their development above t their imposts, and the decoration of the compartments.

The geometrical arrangement of the ribs has been sufficiently explained; it merely remains to state that the side arches, which, in rooms containing free supports, connect these together and with the walls, make strong archivolts and smaller ribs necessary and desirable on both structural and esthetic ground ; if the side arches support heavy loads, as those of churches support the clear-story walls, or those of warehouses, cellars etc. support goods, furniture, implements, men, and other extraneous loads, they must be still stronger. Rooms containing several aisles with raised central aisle require very strong longitudinal pier-arches, with arches of less strength to connect the supports and serve as transverse arches, but ribs to support the compartments of the vault, their strength proportional to the weight of the vault. For such vaults to produce the impression of great strength, that the entire building may have that of power and reserved force, archivolts and ribs must appear massive in proportion to the compartments of the vaults; for lighter constructions to appear light and graceful the side arches are quite unnecessary in lightly loaded vaults and should be replaced by ribs.

Ribs and side arches act like girders and loaded beams of curved form, Fig. 167; their strength increases more rapidly with the depth than the width, but the fibres most distant from the neutral axis are most severely strained. From this results for structual reasons the requirement relative to ther form of section, that its height should exceed its breadth, that it should be strong at top and bottom, while it is allowable to diminish the section between these two limits. In the older mode of vaulting, when the separate courses are perpendicular to the axis of the compartment, the ribs and arches are strengthened at their upper edges, Fig. 167, against which the compartments abut; but this addition is unnecessary in the diagonal mode of vaulting; so strong ribs and arches convey an impression of strength, and the possibility of reducing the section between intrados and extrados allows the use of curved mouldings, while the intrados fulfils its function as a massiv round. The sections and proportional dimensions of unloaded or lightly loaded ribs may be determined independently from the conditions of loading

the conditions of loading. The German Renaissance decorated by fillets the ribs of ribbed vaults constructed according to Gothic principles, and which make the light loading evident. These ribs have a very pleasing effect where used; the rows of leaves on both sides are decorated by beaded astragals, cable mouldings, etc. The sections of strong bearing ribs, in which mediaeval architecture was very fertile, are yet restricted within very narrow limits; the lower edge alone appears most powerful and bold when treated as a round or pointed bowtell, which at a distance, has a more energetic effect than the round, which may also be replaced by a cove or a sharper edge; other forms are inferior to these. The Middle Ages created in the sections of the ribs not merely members peculiar to its architectural styles, but corresponding to the developed vault and of enduring value; leaf-mouldings with beades astragals or bands, expressing the relations of the ribs to the vaults as supporting members, harmonize well with the sections of the ribs. The mediaeval motive of using bands set with precious stones between rounds and hollows is also very appropriate for the decoration of the ribs, and is effective, even at a considerable distance, where other forms become indistinct.

Only in vaults close to the eye may individual mouldings be enriched and divided into smaller parts, yet even then a bold treatment of the rib will be best.

The side-arches supporting the walls must have breadth as well as strength, in this lying an essential difference from the smaller ribs, their different decorative treatment being based on this. The breadth of the side-arches is determined by the thickness of the walls supported, and since the strength of the arches increases with their rise, the two requirements of breadth and strength will be sufficiently satisfied, iff they are built of several rings or courses, whose maximum depth is determined by the depth of the stones as quarried. The side arches accordingly consist of two or more rings of arches according to the thickness of the wall and the loading, and these may be arranged in half or full steps as required, so that the side arch produces the impression that the walls themselves, have laid open their interiors. The simplest and most appropriate mode of profiling the side aches consists in arranging their sections in steps or 'orders', whose alternation of light and shade gives the boldest effect; their relation to the loading compartments is shown by the elastically curved rows of leaves with some fillets, Fig. 171. If the profile is to have a richer form, the angles may be replaced by separate groups of a round between hollows, giving an impression of energetic force and if the lower edge of the stepped arch is to be strengthened in reality as well as appearance, a pointe

bowtell will best fulfil this purpose. We thus rationally reach forms introduced into the grandest mediaeval churches, and can never dispense with model profiles of the 12 th and 13 th centuries in similar problems, but all the labored refinements, such favorites in the late Middle Ages, should be set aside as practically worthless, though interesting historical.

As the side arches support the vaults, also keep the piers apart and also connect them, their horizontal lower surfaces may receive band-like patterns expression this connection.

Smaller vaulted rooms, whose piers are connected by side-arches and covered by ribbed vaults, do not require massive side arches if not exposed to unusual loads; such arches may well be treated as broader ribs for small and lightly loaded vaults principally acting as spanning arches. The wall-arches serve as abutments on the walls for the compartments of the vaults and will then be portions of a side-arch, so that the other sections may be obtained from that of a rib by doubling or halving its breadth, Fig. 172. It is then correct and one of the simplest and cheapest decorative expedients to replace the angles of the ribs and arches by chamfers or coves, to increase the effect of light and shade.

If columns are connected by arches, Roman and Renaissance architects treated these arches like the classic architrave, even forming coffers in the under surfaces of these archivolts. They either were wrong in treating arches like curved beams of stone, or our ideas of the meaning of the form of the architrave must be incorrect, which cannot be the case. The architrave form as a supporting stone beam above a colonnade, was peculiar to Grecian architecture, its division into several horizontal divisions, and the decoration of its under side by band-like patterns, expressed the idea that the columns should be connected by a tightly stretched band, uponnwhich a load might be laid without causing it to bend. But the Greeks themselves employed this architrave form to enclose windows and doors, evenusing it as an archivolt at the aqueduct at Athens, and it therefore becomes untrue, or other ideas were associated with these forms; Roman and Renaissance masters here simply accepted the Grecian forms, perhaps without understanding the ideas associated with them by that people, which appear to have differed from those we have been accustomed to connect with the architrave.

The Classic styles considered an opening in a wall as merely a hole, separated from the masonry of the wall by a bordering frame; but the Middle Ages looked on an opening, producing the appearance by its simple splays or recessed steps, as if the wall had opened of its own accord, laying bare its interior.

It is evident

Bordering frames are evidently not wanting even in mediaeval walls, but are arranged beneath supporting side-arches, which play the chief part, structural elements predominating, even in case of wheel windows and decorative works. The archivolt constructed on the Graeco-Roman principle unites well with the mediaeval vault, so long as the pier affords separate supports for the imposts of the arches, so that each arch may be freely developed; but if the imposts are so formed that the ribs and side arches intersect and interpenetrate at their ends, the arches cannot be developed throughout their extent, the piers then become clustered piers as in the best mediaeval period, and the archivolt has then lost its significance, and is it preferable to treat the ribs and side arches in accordance with mediaeval principles.

Ribbed vaults, like domes and Roman groined vaults, require keystones for structural reasons, though light vaults need not be unnecessarily loaded by the keystone; but if they require great strength, the diagonal ribs must be considered as projecting arches, orpointed arches may be used, requiring special loads at their apexes. The keystone is supported by the ribs and is most appropriately decorated by a suspended flower, a garland of leaves and flowers, allegorical representations, shields, heads, etc., and its width may correspond to the gre greatest width of the arches at the point where the ribs abut against it, Fig. 173. If keystones serve for suspension of chandeliers, or ropes pass through them, they must be perforated, and their decorations be arranged around the central opening; if bells, materials, etc., are to be hoisted through them they must take the form of a circle of voussoirs, and their decorations must be treated in accordance with the principles established for keystones of domes.

Several kinds of keystones are found in ornamental vaults, subordinated to each other in rank. The principal keystone, each vault having but one, should perhaps be decorated by sculptures, heads, etc., the inferior ones by shields, symbols, etc. while those of the third and fourth rank receive rosettes and leaf-ornaments. Both the Middle Ages and the Renaissance tre treated keystones as massive, suspended, forms or pendants, which are especially appropriate if the vaults must either be heavily loaded, when they must appear heavy to the eye and be massively treated, or if intended to receive chandeliers, when they may have the forms of graceful suspended chandeliers. To use pendants for merely decorative purposes, when they have no meaning whatever, is one of the many eerors of the later Middl Ages, and must be considered objectionable.

For the decorative treatment of the surfaces of the compart-

ments, we first have to consider them only so far as they are unplastered, or their construction is visible. The earlier Middle Ages almost always constructed compartments of vaults of cut stone, sometimes with unusual dimensions, so that the massive vaults could even resist fire, requiring correspondingly powerful abutments and flying buttresses. The great activity of building during the 12 th and 13 th centuries demanded a rapid mode of construction, the vaulting requiring much time and money. No attention was paid to decorating the compartments. It was toilsome to prepare the stones, that were not large, and were mostly placed at a considerable distance from the eye, so that little was done to esthetically treat the vault. Neatness and accuracy of execution, a soft and yet clear play of light and shade on the surfaces of the vault, resulting both from their arrangement and the general plan, remained during the entire Middle Ages and is now the principal requirements for a pleasing effect of the vaults, which was further heightened by the bond used, and by the texture of the visible surface and the lines of its joints.

Modern vaulted construction seldom uses cut stone but commonly brick for filling compartments of vaults; the most antural decorations consist in forming a border and in the use of decorative bonds; the more carefully the vaulting is executed, the more pleasing will be the effect obtained; the mosaic-like joints of brick masonry have an appearance allied to that of textile fabrics, and an analogy in the treatment of vaults thus arises, to that of freely suspended tapestries and of textile fabrics, a space-enclosing masonry recalling the tent roofs, both by its structural bond and its external surface, that were suspended between pillars for protection from light, wind and weather, external enemies and inquisitive eyes.

e. Cloister Vaults.

Not much may be said of cloister vaults additional to the preceding discussion of vaults; they are the converse of groin vaults, because, though produced by intersection of tunnel vaults, all those parts are retained, which are omitted in groined vaults. At the line of intersection, the bond itself forms strengthening ribs, kaing separate ribs unnecessary; a keystone is required in domes and ribbed groined vaults, also cloister vaults; compartments need the same treatment as in compartment vaults, and cloister vaults on polygonal plans approximate in form to domes, whose decorative treatment they also follow.

3. Renaissance Vaults.

The Renaissance, when not directly using Roman or mediaeval vaults, usually decorated by painting or stucco work, general-

lyemployed low compartment vaults in combination with the so-called welsh-groined vault, which likewise afforded large surfaces for decoration in relief and painting. Such compartment vaults were mostly vaulted from their angles toward their centres, Fig. 175, and are more or less modifications of domes and cloister vaults in combination with portions of tunnel vaults, and may be decorated by forming borders, a greater prominence of the centre, or by accenting the transition of one form of vault into another, in accordance with the use of decorative bonds; these accentuations may be produced by projecting ribs, whose purpose is more decorative than structural, and whose intersections may be enriched by keystones of all kinds. Compartment vaults of this kind are less suitable for heavy loads the flatter they are, and are only justified by the most careful construction and the best mortar, seldom remain unplastered, but are chiefly arranged with a viet to decoration by painting and stucco.

To the Renaissance vaults may be added fan vaults, derived from ornamental groined vaults, and introduced in the late English Gothic, though in construction more nearly allied to Roman and Renaissance vaults. They are really combinations of annular surfaces, and therefore surfaces of rotation, whose sections may be circular or otherwise, so arranged that the interspaces existing between their upper bases, are either filled by domes, segmental domes, or pointed vaults, Fig. 177; if the half diagonal is taken as the radius of the vault instead of the half side, diagonal sections of the vault are semicircles; and right sections are pointed arches, whose crowns are lower by the difference of the half diagonal and half span; a sharp and gradually vanishing intersection line of convex curvature rises from them to the apex of the vault, Fig. 178; each compartment of the vault is borne by one support, and is in plan a square portion cut from an annular surface of circular section and these surfaces closely join each other without leaving any gaps between them.

These fan vaults have something very characteristic in their external appearance and vividly recall the folaige of the fan palm, uniformly spreading outward on all sides, and must always be decorated by accenting the horizontal lines in accordance with the horizontal lines of stone construction. Very pleasing decorative motives are connected with the domical surfaces used used for filling the interspaces between the compartments of the vault, circular in plan, and the arrangement of semicircular diagonal sections leads to a peculiar treatment of the keystone. Arches are unnecessary in fan vaults, mostly not harmonizing with them, but constructions in stone are possible,

which consist of a series of fan-like ribs connected together, their interspaces filled with stone slabs. English mediaeval fan vaults are generally based on this principle. (Viollet-Le-Duc suggests fan vaults built of cast iron plates, each decorated, all being bolted together, and supported by an upper frame-work of iron beams. Such has not yet been built.).

Chapter 11. Columns.

1. General Considerations.

We cannot critically examine all the orders of columns that past architectural styles have produced, but the problem here is only to seek that generally valid point of view, which may lead us to the treatment of the columnar orders.

Ceilings require supports to receive the load and transmit their downward pressure to the foundation; the external walls and the partitions, as well as the columns and piers, act as such supports. The load always appears very massive and bulky in comparison with the supports, the idea of weight being always associated with bulkiness; to receive these masses, it is both appropriate and pleasing to enlarge the upper ends of the supports; the load must have a firm support and must be distributed over a large area of the foundation. All architectural styles therefore characterize by a capital the end of the support receiving the load, and usually by a base the end transmitting the pressure to the substructure, these intermediate members not only fulfilling known material purposes, but also characterizing the nature of the supports.

For round columns, their capitals and bases are chiefly transitional forms, changing the circular support into the square form of the abacus and the plinth; all nations have compared the capital to the head of the human form, and the base to its feet. The different functions of the upper end of the support, which elevates a load or an object in the air, affording it a resting place suited to its form and dimensions, and forming a transition to the support, were more or less clearly understood and expressed by different nations. The lower end of the support was not characterized at all, as if the support was driven in the earth like a pile, or it was formed like a cushion or plinth, or even took the form of an animal, on whose back stood the column. The supports themselves were regarded as unyielding structural members, and were decorated by parallel stripes; in memory of their original purpose, as merely serving to support a light tent roof, they were sometimes represented as being wound with tapestries.

These general considerations of the formation of supports were not only controlling during past times, but are so still,

and will so remain for all future time. Yet they are modifie in detail by the different nations, as well as in accordnace with the problem to which they were applied, and their connec tion with other architectural details. The different functio of the columns restricted their forms within certain limits, a and are first to be carefully understood, if one wishes to review the multitude of forms of columns, that have arisen in all parts of the world. To discover all the ideas that influenced the different races in the formation of supports is quit impossible.

Why Egyptian columns take their special form and no other cannot be explained, but only this may be discerned, that a need clearly existed of distinguishing between the upper and lower ends, that the leaves, stems and flowers of the lotus and papyrus were found suitable for covering the supports of a tent roof, and that the practice of winding tapestry about col umns is very ancient. All Egyptian architecture creates the impression that the whole building was conceived as an imitation of the tents of nomadic hordes, that settled in the well-wooded Egypt, and the naturalism in the treatment of the color ing permits the conjecture that the idea of a support, whose capital should express the conflict with a burden, is not a primitive one, but that of holding-up something, and of crowning the upper end as being the head of the column, stands in the first place, together with symbolic ideas not now understood. That the Doric column is closely allied to the Egyptia can scarcely be disputed, as it essentiall differs only in the form of the capital, in which the idea of receiving the load of the entablature on a special cushion-like support appears to have been originally expressed by pointed leaves with recurved points. Whether this was actually the idea the Doric capital was intended to embody, or another now unknown to us, can never be determined with absolute certainty. The forms of the row of leaves with recurved points, not only employed as a supporting but also separating member in all Grecian architecture, and as an imitation of this in Roman architecture to connect two entirely different objects, appear from their derivation to be modifications of primitive form-elements, such as likewise are represented in the leafy crowns of Egyptian capitals, and in Persian and Indian columns, that remind one of fringed spear shafts. If we wish to retain these forms of leaf bands, not historical but practical and technical reasons must determine their character.

A peculiar form of capital, later fully developed in the Ionic capital, was introduced in W. Asia; the cushion appears to be the motive for all such capitals; this cushion serving to

supp the entablature. We also see on representations on vases the Ionic capital directly used as the seat of a figure, just as the Doric capital was used in sepulchral monuments to support a figure, palm, or an acroteria. However the form of the Ionic capital may have originated, its origin as well as that of the Doric, has no significance for our architecture, since the circle of ideas of ancient vases lie wholly outside human ideas in general and those generally valid.

The motive of the capital with two different forms of sides, perfected in the Ionicccapital, will always remain indispensable to the architect; when two directions are to be made decidedly prominent, mediaeval architecture did not exclude the two-sided capital. But if the Ionic capital is to be used for the angle column of a building with porticoes, which is not in accordance with its nature, a happier solution must be sought, than that found for similar cases by the Greeks. We can only designate such unskilful expedients as errors, with those for which the Romans have been so much blamed, and that have been so thoughtlessly imitated by moderns, and which are scarcely better than the aberrations in architectural forms permitted by the late Gothic or late Renaissance.

As in the older Egyptian capital, the echinus of the Doric capital is merely an undeveloped bell; with it is allied the Corinthian, just as the Egyptian bell capital is to the latter but the bell capital of the Egyptians is fully developed on all sides, having no proper abacus, and the Corinthian retains the abacus, and very fully developed scrolls and leaves support the angles of this. Two principal forms of flowers, the rosette, and the palm, as well as half-developed buds, fill the interspaces between leaves and stems, and form terminal and dividing parts of the stronger branches, while the smaller branches disperse in a free play of lines. The Corinthian capital is no longer, like the Egyptian beel capital, a cluster of similar flowers and leaves bound together, but plant forms grow up around the bell in a way that betrays a thorough study of nature by the Greek sculptor; if the bell be largely visible, as in the Tower of the Winds, it is closely covered by a row of applied leaves. A second row of leaves covers the lower ends of the first; if one row is composed of uncut edged leaves, like the upper ones at the Tower of the Winds, or the lower at the Monument of Lysicrates, as a contrast to these, the leaves of the second row are deeply serrate and have deep incisions or eyes, such as are not only found on the Acanthus, but on many Compositae, the Thistle, Poppy, and many Umbelliferae. It is very generally the case that no particular plant form is imitated in the Corinthian capital, but special and characteristic

characteristic parts are borrowed from the plant world, and these are developed in accordance with the laws of growth of actual plants, thus creating an ideal Flora, whose foliage seeks those parts of the capital geometrically most important, the ends of their leaves and branches recurving in free growth or rolling up under the abacus, their flowers appearing to strive for light just as flowers do in nature. All the separate parts of the completed Corinthianccapital are in the best relation toeeach other, but the Roman forst becam petrified, as if cast in a mould, naturistically swelled and yet dry. Th The motive of the Corinthian capital has become so indispensable in architecture that it was not only sometimes used in the Middle Ages, but was so beautifully developed, that some examples eqaul the Grecian capital.

We may almost say of Roman capitals, that whatever in them is good is old, and whatever is new is bad. The changes made in Grecian architecture by the Romans had no reference to the original meaning of the forms, excepting the wholly external and chiefly practical. The Doric capital is almost the only one, in whose transformation an improvement is to be discerned it has indeed become entirely distinct from the Grecian and has thrown aside many peculiarities of that, thereby gaining in usability, especially for buildings composed of several stories, where the different orders of columns are arranged above each other.

The Roman Composite order, first developed by combining form from Ionic and Corinthian capitals, for use in buildings of several stories and to enrich the repertory of form, may justly be thrown aside, employing the gracefully decorated Corinthian like capitals of the early Renaissance in its place, that vary the motive of the Corinthian capital with a free play of form

The Tuscan order, which the Florentines of the 15 th and 16 th centuries preferred from local predudices, holding it to be an invention of the Etruscans according to statements of Vitruvious, and also for practical reasons, it being the simplest order, harmonized well with rusticated masonry, is justified as a kind of reduced Doric order, or as being thellowest type of a complete order in the classic sense, although opposed to all Vitruvius's precepts, dutifully obeyed by the Renaissance we should not employ it merely because the ancients did so, unless it suited our design in esthetic propriety. The rigid precepts of Vitruvius and the whole hocus-pocus of antique architectural forms, not only modules and parts, but triglyphs and metopes, viae and guttae, mutules and dentils, etc., should be thrown aside as soon as they no longer fulfil any real purpose, their original sense being chiefly unknown to i

us or not corresponding to our circle of ideas, has no binding force on us. We have thus saved sufficient of the classical columnar orders to not ignore them or throw them entirely asid aside, but have sought to free ourselves from their traditional constraint.

No need here exists for troubling ourselves about the merely historically important form-treatment of Early Christian, Byzantine and Mohammedan capitals; mediaeval architecture alone shows new ideas in that direction, not valueless to us. It preferred to accent the capitals, and the entire treatment of the capital, as in the Corinthian, consists of decorative coverings on bell-forms, in carving low reliefs on convex transitional forms like Romanesque cushion capitals, in a combinatin of both, a favorite Romanesque feature, lastly during late Gothic, in transitional forms of all kinds, where the transition from the round column to the square or polygonal abacus is not made by a regular curve, but by various changes of section and modes of corbelling out, forms both piquant and pleasing, especially justified when the purpose must be satisfied by the simplest means, as in buildings for ordinary purposes, in iron architecture, etc.

By the study of the early Gtohic bell-capital much may be learned of value fro treatment of capitals in general, and eqequally so, whether the foliage approximates acanthus leaf-forms or those of our northern Flora. This first comprises the division of the masses best suited for working theo capital from the rough block, the development of many peculiarities in the foliage itself, based on very careful observation of nature, the treatment of the bell, to which the foliage is applied, and its connection with the abacus. The mediaeval capital is best adapted to vaulted construction in many ways, and the mode of its formation is better suited to the clusterd pier, than any other form of capital, and which is required by developed vaulted construction, while antique forms of capital correspond to the column as an isolated thing, that can never be halved or quartered so as to be pleasing. Whenever Renaissance masters have done this from eccentricity, awkwardness, or poverty of ideas, or even treated the caryatid substitutes in this way, only monsters have been produced, the imitation of these forming one of the many monstrosities of our modern architecture.

The principal gain in the treatment of the capital due to early Gothic, consists in being taught to make the height and projection of the capital entirely independent of the diameter of the column, and to make the vaults in harmony with the mass of the pier and with their loads. Proportions of classic co-

columns harnonize so perfectly with their entablatures, that essentail variations therefrom are impossible without injury to the character of the entire order.

Where the height is fixed by the general harmony of the architecture, it is not possible to firmly adhere to the proportions of the classic orders without recourse to the expedient of placing it on pedestals, or being troubled by inconveniences of all kinds. Only in the same clas of problems presented to the classic architect can the proportions of the orders be strictly retained, and Renaissance masters have frequently found themselves embarrassed in church architecture, not able to free themselves from the constraint of the antique, but compelled to arrange the plan to suit the arrangement of the columns, instead of the converse. One can then only consult mediaeval architecture, unconstrained by tradition, that determined the proportions in accordance with the problem for solution, with artistic feeling as sound as the Grecian.

Classic styles almost always striped the shaft of the column with flutes, which enhanced the impression of the rigidity. These flutes were replaced by gilded stripes in columns of the nobler kinds of stone, of metal, or if placed in the interiors of apartments. From esthetic points of view, it is very disadvantageous to treat large and massive columns without flutes, as they appear rather heavy. though this is well suited to small and slender columns.* According to classical ideas, columns always require to be diminished, both when free and ahen connectedwwith each other. A swelled shaft is justifiable

A swelled shaft is justifiable if its own weight and its resistance to crushing must be considered; in the first case its lower diameter should be greatest; in the second the enlargement should be more nearly at the middle of the shaft. Massiv Doric columns were formed in accordance with the first principle, but very tall Corinthian columns usually agree with the second. If very short and thick columns are employed for supporting massive vaults, whose ribs cause thrusts in many directions, a considerably enlargement of the column appears preferable to none at all. An enlargement is peculiarly proper and desirable for small metal columns exposed to crushing; but it is nonsense to enlarge columns that are not free, but are grouped, as done in the late Renasisance and sometimes imitated now from poverty of ideas. Swelled pilasters should never be used, nor another favorite blunder, rusticated columns, their separate drums treated as rusticated blocks, while their capitals and bases are completely finished. This nonsense was a favorite idea in even the best Renaissance era, and is modified in various ways; all the drums of the half columns are

either rusticated, when they appear as if incrusted with the deposits from a hot spring, or rusticated square blocks alternate with circular drums as if the money had been expended in finishing the former, or the stones are all cylindrical, half of them retaining their rustication, so as to interrupt the flutes of the column and seeming like rough bands placed aroud the column. No one possessing a pure, artistic feeling will deny that Renaissance masters well understood how to produce a magical effect with the means chosen by them, and to obtain good proportions of details and of the whole, that will always continue marvellous; but a poem may be patched up from pompous phrases and remain nonsense, though pleasing to the ear; the worth of architecture is not merely in its pleasing effect, but also mainly in the choice of motives for special purposes and means, and it must always be considered as completely without architectural meaning to combine motives entirely at pleasure.

The shaft of the column always rem ins a unity, and can never be considered as a unified combination of many parts, like masonry; it may indeed be wound with tapestry, as masonry may likewise be covered, and in this way is all decoration of the column by reliefs or painting justified; the shaft of the column should be divided into a shorter lower portion and a higher upper part by an intermediate member; the lower part of the shaft is either left smooth to avoid injuries to the flutes from passers, or an annular band is interposed, projecting from the lower part of the shaft to make the lower third of the column appear thicker, or to distinctly separate the smooth or decorated lower portion from the fluted upper part. But to treat a column as if composed of courses of stones is in complete opposition to true artistic conceptions, that always consider the column a unity, although composed of parts, like the human form, though not produced by apposition of unities.

If we wish to increase the thickness of the wall by rectangular or semicircular projections, as very frequently done in late Renaissance, and the treatment is to harmonize with the construction of the wall, every reminiscence of the classical column is to be thrown aside entirely, and a treatment of the capital is only justifiable as being a termination to these projections from the wall.

Finally, to treat the columns as twisted forms is always objectionable in architecture, only proper and possessing meaning in art-industry and purely decorative works, where the leading idea of weight recedes into the background. But fluting the column loses its purpose and meaning in all works of the minor arts, to which also belong shrines or cases with

decorative and symbolical meaning, whose principal types retain the forms of actual buildings.

The motive of spirally twisted forms is suited to all combinationsof tie-rods, as opposed to struts, as well as for constructions of tubes, partly perforated and partly entire, and are employed for the most diverse purposes.

A word still remains in reference to caryatids, atlantes, hermes figures, and whatever else remains in the service of architecture, of the more or less thoughtful works of classic sculpture, as well as medieval figure columns etc. Every one that uncritically admires everything Grecian and is amazed by it, merely because it was invented by the Greeks, will denounc as a heresy the mere question, whether the famous caryatid porch of the Erectheium is entirely beautiful. Perhaps I may alone esteem it a Barocco idea, however beautiful the columns, if it have no symbolical meaning, and to unpleasantly feel the execrable disproportion between it and the architecture. There is not merely lack of harmony of the animated figures and the stiff architecture they support, but still more in the proportion of the supporting masses to those supported. Had the Middle Ages ever permitted a canopy to be supported by statues of Christ and his Apostles, what a clamor would have been raised at such bad taste. But if we wish to retain the idea and regard it as original for the Greeks to use figures as architectural members, we must still consider this freak as exceptional acquiring no greater value by repetition; nor should we forget that caryatids and atlantes were used as if pilloried, or in an even more debased sense, this clearly indicating the permissible limit in introducing human figures as architectural members; the use of the human form as a caricature as a substitut for architectural members is proper, if boldly treated; but the contradiction between the movement of human or animal form and rigid architectural construction can never be wholly effaced, if these are anything else than decorations of the architecture. Figure decoration of all kinds is not only proper, but even desirable in architecture, being the highest means of ornamentation, but it should not replace architectural details These considerations entirely disappear in the minor arts because the idea of weight is not there predominant, and which causes in the greater arts and in construction the appearance of rigidityiin construction.

Renaissance architects were probably only acquainted with caryatids and atlantes through Vitruvius, and created miracles in architecture without the aid of these extreme artistic expedients; but our era deluges us with figures of sheet metal and plaster of paris, most without beauty, sense and meaning. These classical

These classical heroes and demigods should not be condemned, but should be left to the places for which they are alone suited, to pure decorative art, to interiors of apartments, to humurous purposes, and the minor arts.

The base of the column was considered a base-stone or cushion for distributing the pressure of the column and its load over as large an area of foundation as possible. Hardly any other architectural form has become so firmly naturalized and found such wide acceptance as the Attic-Ionic base, Fig. 179; it has always been used from the best Greek period until now, although with many modifications, and the same decorative motive recurs in each style, of treating its convex torus as a soft and yielding cushion, as a row of leaves, or a twisted rope, that seems to retain the foot of the column in place. The scotia separating the two toruses is preferably decorated by a row of slender leaves.

We have briefly considered the treatment of the column according to the ideas of different nations and the problems to which it was applied, as well as its connection with other architectural members. The purposes for which columns are generally used are principally works of architecture, of art-industry, or of the minor arts; the first requires the function of support to be strongly expressed, but in the others, this recedes behind other functions. The classic styles not only introduced in their orders different style-tendencies, but also tones corresponding to the character of a particular building, as well as to its different stories, tomanly strength and gravity in the Doric style, to grace and dignity in the Ionic, and to magnificence in the Corinthian.

In accordance with these tones, the function of supporting is more or less strongly expressed in different kinds of columns, the treatment of the mass of a building passing from gra grave to graceful and thence to rich. The idea that the column is to suppor or raise an object, the function of support, then receding into the background, is most strongly expressed in classical memorial columns and in the rows of columns placed before facades by Roman and Renaissance architects, and crowned by statues, so that one might well say of these column that they supported nothing; yet to throw them aside for that reason would be to overlook one of their most important functions and to forget that a large number of Grecian memorial columns would be condemned, as well as many Roman and Renaissance works.

Memorial columns would likewise have a freer range of form, because as monuments, the function of support recedes, and as the possibility of ascending to the top by a winding staircase

becomes a principal aim, a sprial arrangement of such a column is not only sensibèe, but indeed becomes requisite, and a motive of the manifold structural and decorative compositions, that may be derived from it. The idea of the memorial column may thus be developed from the simple sepulchral monument to the formal tower through a series of possible solutions.

2. Columns in Detail.

In regard to the treatment of the details of columns, and especially the capitals and forms of shafts and bases, numerous reflections may be made, assuming the classic orders to be not accepted as something consecrated by tradition and above criticism, but that the entire progress of architecture since the classical period, as well as that due to the Middle Ages and Renaissance, be taken as a basis of these considerations.

a. Form of the Capital.

The most primitive treatment of the capital in the oldest styles already divided it into three parts, the Bell or concave or convex principal portion of the capital, whether in the form of the Doric abacus or the Corinthian bell, the Abacus, and the Necking. The principal portion of the Doric capital is the strongly projecting echinus Fig. 180, which is separated from the shaft by several annulets, or rather the row of leaves painted on the echinus and which form a continuation of the flutes, is closely encircled by these annulets at its base The abacus is square, circumscribed about the echinus, Fig. 181. The breadth of the architrave exceeds the upper diameter of the column supporting it, but is less than the width of the abacus, which, as well as the echinus, is but partially loaded Fig. 182. The architrave does not rest directly on the abacus an imperceptibly raised central portion being left to receive it, that the angles of abacus are not loaded. Fig. 183. Some capitals, like those of the Temple at Paestum, have a second row of leaves beneath the neck-bands, whose points are slightlyr recurved. If the architrave were placed directly on the abacus, the capital would be unsymmetrically loaded, and the strongly projecting angles might be broken off.

Roman Doric capitals were perhaps partially imitated from late Grecian examples, no longer existing, and more freely represent the ground idea of the Grecian Doric archaic capital, retain the adopted motive though without strictly adhering to its form, and vary the theme in manifold ways; the Renaissance followed this Roman mode of treatment, sometimes combining forms resembling Ionic and Corinthian with the Doric.

The first essential alteration of the Doric capital by the Romans consisted in lessening its projection, giving the architrave a breadth only equal to the upper diameter of the column the e

the echinus then becomes of less importance, its section approximating a quadrant, and the smaller projection of the capital required compensation in its increased height or that of its necking, that the mass of the capital might not be reduced too much in proportion to the column. The neck was then separated from the shaft by a bolder member, an astragal with small fillet, or a beaded astragal, and was decorated by rosettes, palms, etc., the abacus being ornamented by a row of leaves or a cyma. Besides the normal capital, two very fine forms have remained to us, one from Pompeii, the other from the Baths of Diocletian, Fig. 184; the necking of the first is a flat curve, while the cyma of the other is not formed like an echinus but is composed of vertical leaves. Several kinds of capitals may be composed of forms taken from different capitals, using two rows of leaves, and are suited to the most varied problems by their greater or less height, but lie within the limits of the motive of the Roman Doric capital.

The Tuscan capital, Fig. 185, restored in accordance with Vitruvius, is nothing but a simplified Roman form, just as the Tuscan order is merely a reduction of a classic columnar order to the most essential motives. This order was much used in the early Renaissance as better harmonizing with rusticated masonry, and combined with that, it is especially suited to fortifications, engineering structures, city gates, barracks, and massive ordinary buildings.

The abacus of the Doric capital projects its angles considerably beyond the echinus, making its under side visible; the Romans decorated this lower surface by sunken panels, thereby weakening the angles, already in danger of breaking under the load. If the abacus were made octagonal, these corners disappear, though the character of the capital changes, and it would appear compressed and only suited to receive an impost block of the same form. The angles of the abacus might be reduced by making the diameter of the echinus equal to the side of the upper part of the abacus, and so profiling the edge of the abacus that its square under surface would be circumscribed by the echinus. The abacus then loses its meaning as a covering block and takes the character of a special support for the load, Fig. 186; the under side of this support must then be octagonal and pass from this into a square at top. All these forms of abacus have their meaning, especially when the capital receives vaults or arches, when a braod mass is placed on a proportionally thin support; this is especially true of iron architecture and of iron columns supporting vaults.

Finally, one means of supporting the angles of the abacus consists in employing some decorative motive on the capital,

after the precedent of the Renaissance, to fill the space between the echinus and the angles of the abacus; the Renaissance used for this purpose small heads of animals and men, decorated the capital by dolphins or cornucopias, garlands of flowers or clasp-like volutes, etc., according to the employment of the capital in buildings more or less richly decorated.

Roman and Renaissance architecture almost always crowned the abacus by a row of small leaves; the profile of the abacus is varied in different ways, Fig. 187, according to the projection desired, which results entirely from the geometrical construction of a circle with inscribed and circumscribed squares, wh where it is desired to avoid a projection of the abacus beyond the echinus; the use of the capital for aspecial purpose, or the material in which it is executed, will decide the choice of a profile for the abacus, since any particular profile gives the abacus a particular character.

The annulets separate the echinus from the necking and were either treated by Renaissance architects in accordance with the precedent of the capital from the Theatre of Marcellus as simple fillets, and even as a Lesbian cyma by Scamozzi. Fig. 188

The neck of the column may be straight or concave, or be changed into a second row of leaves, like that of the capital from Paestum, or it may be straight and decorated by rosettes or palm leaves; in Roman and Renaissance architecture it is almost always separated from the shaft by an astragal and fillet instead of which other mouldings may be introduced. Fig. 189.

The classic orders were devised for post-and-lintel construction; when they were combined with vaulting by the Romans a very troublesome inconvenience arose. If the columns were connected by an architrave and arches were thrown across above this, the architrave was not loaded and so became unnecessary; if it was omitted in the interior of a building and retained on the walls, the columns intended to receive the arches were either higher than those attached to the walls, Fig. 190, or the arch required to be stilted; both modes of arrangement possessed unpleasing peculiarities.

Roman and Renaissance architects hit upon the truly consistent though unmeaning expedient of placing above the capital a fragment of the architrave, or sometimes a part of the complet entablature with frieze and cornice. Aside from the fact that such a block of the architrave is meaningless, when the column and the lower part of the vaults are viewed diagonally, its mass appears ungraceful, heavy and unpleasing, this effect becoming still worse with a capital of the graceful Corinthian type. The Grecian Doric capital is least ungraceful, its widely projecting and strong echinus very well supporting a

broad mass; but the severity of this order is more decidedly opposed to the entablature block than are the more pliant form forms of Roman architecture.

To place the imposts of arches and vaults directly on the capitals, as sometimes done in early Christian architecture, andwhich is also permitted now, appears most unfavorably of all in free columns. The masses of the vault widen upwards from the impost and require an energetic preparation, and both classic and Renaissance styles know no other means of obtaining this than by the awkward entablature block.

Byzantine architecture made a virtue of necessity by inserting an impost block between the capital and lower part of the vault, also very heavy in form. Yet in this ugly block, never made beautiful by the richest decoration, a motive was introduced, capable of being developed otherwise; it is a support inserted between capital and vault, which can itself be entirely free from the forms of the architrave and may receive a different form in accordance with the special problem for which the columns and arches are used. According to whether the arch or vault requires a larger or smaller supportb between it and the capital, this support will consist of one or more layers, whose differences of section are to be arranged in accordance with the difference of the section of the column and the impost, and the most pleasing proportions of the masses.

The support may properly be crowned by a row of leaves or a cymatium, may be treated as a plain block, be flat, concave, with rosettes, ornaments, decorated necking, etc., or treated as a swelled cushion, and it can form the transition from the round column to the square impost block, to play the part of an intermediate support. in the most varied way. Fig. 191. Mediaeval architecture made the richest use of this support in accordance with the need of raising the base of the pier or column. Even French and German Renaissance sometimes introduced this support or used the classic entablature block, changed by the omission of the architrave.

If a form of architrave remains on the internal walls and also elsewhere, the addition of this support is unnecessary; but it is always desirable to place the arches on the columns so as to connect the mass of the impost with that of the capital, and to have the support consist of a single low course of stone The support cannot be omitted in case of coupled columns, but columns attached to and projecting from the wall need to retain their form of architrave, as walls do all other forms of the entablature in case these engaged columns be not omitted, for there is an essential difference between a broken cornice and an entablature block in theclassic style. For clustered

wall columns, the broken cornice always has an effect as a mass, less unpleasing than the entablature block over free columns; if the columns and capitals are entirely free from the walls, with a broken cornice seen in the worst way, or diagonally, the mass resting on the capital will still be less than for a column free on all sides; this mass may prpoerly be lessened by not allowing the geison with its corona to project more than absolutely necessary at the points where the entablature is broken, while it may project elsewhere as much as necessary, Fig. 192; its chief purpose being to protect the building from rain water running downwards, and this protection cannot be had by a column standing free from the wall unless the geison projected on all sides like an umbrella, which would be very ugly. In drawing columns and the masses supported by them, they must be represented from the most unfavorable point of view, or diagonally, in order to decide on the projections and divisions of the mass; when one form of section passes into another, perspective is not alone sufficient to give a proper idea of the proportions. This is especially true if not only the effect of the mass, but also that of the outlines is to be considered, as in monuments, memorial columns, church towers, etc.; it then being necessary to draw a view parallel to the diagonal of the octagon e f, Fig. 193, as well as a fron view a b and a diagonal one c d, when a transition from the square to the octagon occurs.

The two-sided Ionic capital, whose origin is as obscure as that of Crecian Doric, differs in principle from the Roman Doric capital only in that the characteristic volute-cushion is inserted between the abacus and echinus. The proportions of the different parts evidently differ in the Ionic from the Roman Doric, and the individual motives also have different froms, yet the ground ideas are the same, with forms but approximately similar. The prototype of both appears to be traced to a column originating in the island of Samos, showing the Roman echinus, decorated by leaves but without Ionic volutes. The abacus of the Ionic capital consists merely of an Ionic cymatium or Lesbian cyma, the necking of the column is omitted or is decorated like that of the Roman Doric by palm leaves, rosettes, and similar ornamental forms, according as it resqures more or less height. The cushion is treated in various ways; these being first referred to the front view of the volutes with their eyes, then to the side view. Roman and Renaissance architects really understood how to make the form of the Ionic capital beautiful, although one must admit that the Renaissance strained every nerve to perfect the proportions of Ionic capitals. The reason for this is that neither Roman

nor Renaissance masters were acquainted with the more perfect Grecian Ionic capitals. In the most beautiful, as those of the Propyleum at Eleusis, the cushion is highest at its centre and its section diminishes towards the eyes of the volutes, its front surface flat, with an enclosing border.

In other capitals, as those at Eleusis, the flat surface is treated as a hollow, and in the capitals of the Erectheium the entire cushion is treated like two bands, placed one above the other and hollowed out on the front surface. The angles between the cushion and Ionic cyma are sometimes filled by palm leaves. In the finer capitals, the volutes make but two complete revolutions around the eye; in the doubled cushions of the Erectheiuh a not very pleasing duplication of the motive is produced by the doubled cushions. The capital from the Temple of Apollo at Bassae is doubly abnormal, for it has cushion on all four sides, whose centres are occupied by palm-leaves.

Later capitals, followed by Roman and Renaissance architects treat the cushion as a mere band with a border on its upper edge only, no thicker at the middle than at the sides; the capital thereby becomes lower, which mayoften be desirable, but the cusion loses its distinctive character.

By treating the cushion as a double band, the turns of the volute having free scope, the vaolute and the entire capital become high, making a necking necessary to separate it from the shaft, as at the Erectheium. Renaissance architects sometimes decorated the face of the capital by acanthus ornaments and gave the eyes the form of rosettes.

The facts stated here are evidently but reminiscences; the detail treatment of the capitals must always in relaity be based on a careful study of classic columnar orders, and requires the most careful consideration of new ideas. The side view of the cushion is always formed as if firmly bound together by a band, but the volutes are freely developed on both sides; several beaded astragals sometimes accompany this band, as at the Erectheium, the side of the cushion being generally covered by scale-like, lancet-shaped or acanthus leaves, or even decorated by free scroll-work. Fig. 194.

One of the oldest Corinthian capitals with two rows of leavs that of the Tower of the Winds, even has a square abacus; late later capitals supported the angles of the abacus by leaves or scrolls. The square abacus has an effect too heavy in proportion to the graceful foliage of the capital, and a slightly curved form was therefore given to that of the Temple of Apollo at Miletus; since very acute angles were produced by this curvature, easily broken off by the load, these were clipped so that the abacus was square in plan with curved edges. F. 195.

Centre flowers or palm leaves do not project in plan beyond the angles of the square, so as to unnecessarily increase the dimensions of the block required. If the centre flower is to be covered by the abacus, its edge curves outward at the angle and centre, Fig. 186. These two forms of abacus were first used on the Monument of Lysicrates and an antae capital from Eleusis. The profile of the Corinthian abacus remains a slightly or strongly coved slab in Grecian, Roman and Renaissance architecture, and is crowned by the Ionic cyma; the astragal separates the capital from the shaft, and retains in all these styles the form of a plain or beaded astragal, connected with the shaft by a fillet and an apophyge or cove. This abacus is sometimes decorated in richer Roman examples by a running ornament or by vertical leaves, the so-called pipes.

The Renaissance introduced a freer form of Corinthian-like capital, which bears a purely decorative character and was transformed in most various ways to accord with diverse problems. Mediaeval architecture has done nothing for the treatment of the capital on the Corinthian principle; it first separated the abacus from the capital frequently, even for practical reasons, as the bell of the capital was the work of a sculptor, while the abacus was that of a stone-cutter when not decorated; so the bell itself was crowned by a slab, which was circular, square or concave, according to the arrangement of the capital. The abacus, placed above this bell-slab, could then be square or be suited to the impost of the arch, sometimes polygonal, sometimes circular, or could take a form composed of polygonal or other elements. The mediaeval Corinthian-like capital also received a second innovation for practical reasons, worthy of imitation frequently; it is not wrought from a single block but of two layers of stone, each of the two rows of leaves having its onw bell-slab, so that the lower bell does not appear so much separated as in many classic caps.

Gothic architecture frequently developed the abacus in accordance with the principle just stated as a kind of support, its base set so far behind the greatest diameter of the capital as to avoid any projection of the support beyond the bell. In mediaeval vaulted construction the angles, leaves and buds of the capital appear less like organic parts of the capital, bent downwards by the load, or whose upward growth is hindered by the abacus, than like parts indicating the direction of the ribs of the vault, or like light garlands, that seem to have sprung from the fully organized structural mass as a necessary expression of its nature.

Just as the Ionic capital accents its two directions, mediaeval architecture introduced the motive of grouped corbels to

emphasize the directions, and which are supported by a separat capital, or spring directly from the support, and can carry an entablature or the springing block of several arches, and not only clearly indicate the directions but also lessen the spans Fig. 198. The Renaissance afterwards took up this happy motive and sometimes treated it in the most graceful way in accordance with classic decorative rules. Heads, acanthus leaves and and other forms borrowed from classic modillions, may be applied to such corbel forms as ornaments and decoratively expres their purpose.

b. Form of the Shaft.

Doric columns always have intersecting flutes of flat sectional curvature suitably ending at top and bottom, while flutes of Ionic and Corinthian columns are always separated by fillets, are of semicircular or elliptical section, the latter sometimes ending at top in a row of lightly recurved leaves. If the column be divided at its lower third, this is either done by a broad band, which appears to be connected with the shaft by small mouldings on its edges, or by a bold annular moulding; the projections of the small mouldings should not then exceed the lower diameter of the column, so as to be adapted to the uncut blocks. But strongly projecting annular mouldings, favorite forms in mediaeval architecture, signify that the column is composed of three pieces. Profiles of such annular mouldings, which personify a powerful swelling of the shaft, may be formed variously in accordance with the material, the proportions, and the decoration intended, Fig. 199; their profiles, height, light or heavy character, depend on circumstances and the amount and quality of the decoration, which may be represented by a row of leaves or flowers, a rope wound around the column, a band set with precious stones, or a band with heads or hooks for suspending garlands, etc.

A broad band wound around the column may be decorated by any band-like pattern as ornament in rich decorative work, and the shaft itself may be covered by all kinds of ornaments in color or relief, scale-like, tapestry-like carvings, net-work, scrol work, or suspended ribbons, garlands, and symbolical accessories, which conceal the base of the column. The Renaissance was fruitful in an inexhaustible wealth of the most beautiful decorative ideas, affording many specimens of beautifully decorated shafts of columns.

c. Bases of Columns.

The simplest form of base is the Tuscan, which merely consists of a torus or a base moulding instead of a torus, the plinth, and a fillet with a cove forming the transition to the shaft, Fig. 200. The richer Attic-Ionic and Corinthian bases

retained normal profiles of Roman type in the Renaissance and could scarcely now be displaced, Fig. 201. They fulfill their their purpose in the best way, and are readily decorated by ornamental elements representing the fixedness of the column in its position, and the yielding quality of the cushion beneath it, in the form of small mouldings, cushions and rows of leaves. Ionic bases from Asia Minor have very little importance for northern architecture, with their peculiar proportions and forms, but different variations of the profile of the base have meaning and are justified, and may be developed patrly by simplification or enrichment, partly by increasing or diminishing their projections and heights, Fig. 202. These modifications of the profile principally depend on the position of the eye, columns placed high above it requiring high bases, on account of perspective fore-shortening, and the base may be low when viewed from above; for it is evident that the height of a base viewed in the direction a, Fig. 203, would appear quite different when seen in the direction b.

Just as the angles of the Doric abacus overhang the echinus, producing danger of their being broken off by unequal loading, a vacant space remaining between the lowest torus and the angles of the plinth in the normal classic base, so that the flushing of the angles might be feared. Mediaeval architectur filled these spaces with corner leaves, or sought to reduce them by hollowing-out the upper edge of the plinth, by cutting off its angles, or by increasing the diameter of the lower torus, so that it circumscribed the square plinth, or by combinations of these different arrangements, as well as by hollowing out the angles, Figs. 204, 205. If the diameter of the torus exceeded that of the plinth, it required support, furnished by a small corbel or ornament. All these detail motives were introduced in the forms of the base by mediaeval architecture, but may well be clothed in Renaissance forms. A peculiar t treatment of the bases of columns, corresponding to the capitals composed of forms set diagonally in combination with others, whose changes of section do not occur gradually but suddenly, was a great favorite in later mediaeval architecture, and thus created a motive that may often be used, and is very suitable for cast metal, iron architecture, and wood-carving.

d. Pedestal of the Column.

Roman and Renaissance architecture felt a natural necessity of introducing other features in addition to the normal ones of the orders, that should be more perfectly adapted to the treatment of buildings of several stories; placing one order above another, the great projection of the lower entablature concealed the bases of the columns placed upon it. Perhaps the windows used, required a certain height of wall between

the windows required a certain height of wall between them and the cornice; to make the base of the columnvisible, it could be placed on a separate pedestal of equal height with the window sill, Fig. 206. But this and its cap must now find room between the base and the top of the cornice in accordance wtih the tolerably normal proportions of the orders, which varied within certain limits, the diameter of the column, its height etc., being the dimensions fixed in advance. The scale of the upper story was fixed, that of the lower story with its heavier orders being dependent on it. This scale of the lower story made necessary the insertion of pedestals under its columns which would have otherwise had false proportions. Peculiar forms of pedestals were thus developed for the orders, which require detailed consideration. The height of these pedestals is from 1-9 to 1-5 that of the entire story, or about 1-3 that of the column with its capital and base; the width of the pedestal, that supports the base of the column, should not be much less than that of the plinth of the base, as this would otherwise appear insufficiently supported.

The simplest form of pedestal consists of a die, a cap, and a base; the cap may be connected with the die by supporting and transitional mouldings, according to its purpose, and the richness of the architecture, and the die may likewise be connected with the base by an apophyge, Fig. 207.

Renaissance masters, who kept the orders strictly separate, gave simple forms to pedestals of the Tuscan columns, those more richly profiled to the Doric, still riches ones, sometime decorated, to Ionic and Corintnian, according to the precedent of classic pedestals, Figs. 208, 208 a; a separate necking was also sometimes used, as by Vignola. The band is usually the principal member of the cap, though it is sometimes the transitional member, as on the Arch of Constantine and that of Septimus Severus.

The richest form of pedestal was devised for the Composite order. Although the Composite capital, as a monstrosity, has no importance to us, and the essential difference between the Corinthian and Composite entablatures consists only in the use of both modillions and dentils in the latter, which is but little after all, we shall not be afraid to borrow the richer forms of the Composite pedestal, when necessary. Fig. 209.

Pedestals are important as bases of free-standing monuments, on which something is to be placed, even more than for columns They then become columns or supports of an elevated object, and in this way, both classic and Renaissance styles employed pedestals for columns and supplied them with bases and caps.

In massive arrangements of piers, such as are required by vaulted

vaulted constructions, especially in mediaeval churches, the bases of clustered columns and piers should be treated as massive base-blocks, which, with gradually increasing breadth, distributes the pressure of the pier over the foundation. The offsets of the courses should be softened by any transitional forms, the lower course should sometimes be formed as a bench for a seat, Fig. 210; where a seat is useful, it affords the best means of giving the pedestal a broad base.

Chapter 12. The Pier.

The word Pier denotes so many different things, that it is scarcely possible to give an exact definition; it will here only be applied to those vertical supports, which are not columns, both standing free and engaged to walls.

a. 1. Renaissance and Classical Ttreament of Piers.

Piers always have this in common with columns, that they are intended to support a load and transmit its pressure to the foundation; like columns, they require a footing, a base, an abacus and a capital. As for columns, the capitals and bases form a transition between the form of theppier and those of the load and foundation; but as the section of thepier is almost invariably formed with reference to the architectural details nearest it, the formation of the bases and capitals is simplified.

The classic orders were generally concerned with only free-standing or compound piers. The Grecian Doric style gave wall piers an abacus, supported by a Doric half-recurved row of leaves and finished at top by a small crowning moulding; the cymatium (hawksbill) was connected with the pier by a necking or a few bands, or exceptionally by an Ionic cyma, supported by a beaded astragal, Fig. 211, as in the Temple of Nemesis at Rhamnus. The base consisted of a simple projecting plinth, or a reversed base-moulding. Slight variations in the forms of these capitals evidently occur in the few remaining examples, each individual case being designed in harmony with the entire building in which it is found.

The pier-caps of the Tuscan order of the Renaissance masters are partly very simple as in Vignola, paratly richer and so profiled that the corona predominates, Fig. 212. Roman and Renaissance masters profiled the Doric pier-capitals in very similar ways, but usually left the base entirely simple, consisting of a single offset with or without a transition moulding.

The Grecian Ionic order introduced characteristic forms of antae capitals in most important remaining examples, as the Erectheium and Temple on the Illisus, also in the Propyleum of Temple of Minerva at Priene and Temple of Apollo at Miletus. The two first consist of a band and necking between which were inserted anIonic

inserted an Ionic cyma, above this being a Lesbian, with beaded astragal, Fig. 213. The necking was decorated by palm leaves and separated from the shaft by a small beaded astragal. The two last are the so-called "canopy-capitals", but to approve their form and restless decorations, one must be a blind enthusiast for Grecian antiquity.

Grecian Ionic forms bases of pier and column alike.

Roman and Renaissance Ionic treat capitals of piers as richly moulded abacuses, with almost entire independence of the Greek idea, or as capitals decorated by foliage. The remains of Roman architecture possess so little authority in details, that a great number of these heaped-up mouldings of caps have little value to us, and we can more closely follow the Renaissance, that took the greatest pains to restore the ideal of Roman architecture, with whose decadence it was chiefly acquainted. Fig. 214.

Two forms of pier capitals in Grecian Corinthian are known to us, as in Ionic, these from the Tower of the Winds and two fine capitals from the entrance hall at Eleusis and from Paestum, both being decorated with foliage and figures. Romans almost always used only the Corinthian bell capital with acanthus foliage, which was fitted to the rectangular section of the pier; Renaissance masters used similar forms, or impost capitals for piers supporting arches, which differ little from those of the Ionic or Composite order, chiefly in possessing a richer ornamental decoration than the latter. Figs. 215, 216.

The bases of small piers, like window pilasters, or those used near canopied niches, were more simply formed in Roman and Renaissance architecture, and the mouldings were reduced to their possible minimum, or if the decorative treatment was refined in accordance with the material used (marble, bronze), and the postion of the small piers or columns, the surfaces of the pilasters were decorated by delicate ornamental work or inlaid work, or small columns were treated as graceful candelabra, which is quite justifiable, especially in decorative works. The forms of such minor architecture are of importance in the composition of monuments, reredoses, and similar articles of furniture, related to architecture and furniture. In art works, according to the principle retained throughout the entire discussion, only the Typical of architectural forms possesses meaning, while detail forms require transformation and finer treatment, corresponding to the purpose of the furniture and other objects.

2. Compound Piers after the Classical.

Several modes of forming groups of piers result from the plan of an aprtments and may be arranged in a few typical mot-

ives; 1, two or more piers form a group of elements of equal height; 2, they form a group of elements of unequal height, Fig. 217. The following ground-motives practically result in both cases; a), two piers stand beside each other; b), two are one behind the other; c), two make a right, acute or obtuse angle with each other; d), several piers form a group. These problems occur on facades as well as in interiors, in post-and lintel, and in arched construction.

If several piers are connected in a group of fixed height, each one either requires its separate capital and base, and the piers may then be detached from the wall, affording sufficient space for free developemnt of the capitals and bases, a common plinth and a common abacus may also be added to these; or, the capitals and bases cohere and form a compound capital and compound base in which reentrant or projecting angles sometimes require transitional ornaments to fill the angles, so that the group really forms a whole and does not appear to be merely an external combination.

Transverse connections are not only proper, but in many cases are necessary in compound piers at about one-third or one-half their height, in order to properly bodn together the different courses of stone, each composed of several pieces; this is especially true of brick piers, in which a bond stone must be occasionally inserted. One of the finest examples of transverse connections is to be found at the angles of the court of the Cancellaria at Rome. If the piers of a group are of unequal height, two cases become possible, the capitals and bases of the projecting portion extend around the other, Fig. 218, a; or the pier-caps and bases of the receding portion die against the projection a. The projections of the cap and the projection of the pier must be so arranged that this abutting of the mouldings is possible, Fig. 219. As the cap of the lowerpier must be included within the solid of the projecting one, the cap of the former may extend entirely across the pier as a course of stone, breaking the projecting portion as a band. But this band may remain smooth; or the lower mouldings may be broken around the central pier, supporting a smooth projecting band, against which the upper mouldings abut; or the upper mouldings may extend through, only the lower ones abutting against the central pier; or the entire cap moulding may be broken around the central pier, Fig. 220. If capitals are found at three different heights in a compound pier, one should take care that the cap of the lower pier abuts agains the projection of the highest, Fig. 221, and the courses corresponding to these capitals could then only break the highest pier as smoot bands; any other arrangement would be somewhat disturbing.

Compound piers may have the fault of occupying more space, obstructing the view and hindering admission of light into the room. The separate piers may therefore be in part replaced by columns, Fig. 217 a,. This causes many difficulties; one must first strictly adhere to the principle of considering the column only as a unit, never employing a hlaf, quarter or three-quarter column, or whether he should use these. If one decides to substitute columns for piers, which never require fixed ratio of height to width, he is always somewhat fettered by proportions, and if he seeks to make their ratio of height independent by placing pedestals beneath the columns, it may happen that the columns will appear too slended in comparison to the remainder of the pier, not replaced by columns. If different heights are to be considered in the compound pier, another proportion of the column must be suited to each height, and it would be very difficult to obtain harmony in all parts. These and other difficulties, which especially in churches, will not be diminished but even increased by the use of half columns, formed in accordance with classic models, and one can only avoid them all by emancipating himself from the classic orders, and strengthening the pier by semicircular projections, entirely independent of all classic proportions, and provided with capitals especially composed for each case, Fig. 222. In this way, one attains the formation ofpiers employed in mediaeval vaulted construction, one tendency of which begun in the Cathedral of Autun, but never was further developed or brought to a consistent result, although creating a kind of Renaissance, as far removed from the coercion of the classic as that of mediaeval architecture, or from Gothic, the most extreme phase of its development.

3. Compound Piers after the Mediaeval.

How may the problem of mediaeval vaulted construction be solved by a treatment of the piers retaining everything worthy in the forms of classic architecture, working in the Renaissance spirit, but freed from the restraint of the classic orders, so far as they cannot now satisfy purposes for which they were no not intended? Take the general case of a space divided by piers, each bay of the plan covered by a groin vault, with the conditions that the pier must occupy as little space as possible, the ribs and arches of the vaults be completely separate at their imposts and not intersecting; if we support the side arches by semicircular projections, the total width of the piers will not be less than if these projections were rectangular; the supports of the ribs, if rectangular, would appear too massive in proportion to the ribs, when viewed diagonally, for the moulded ribs would then recede behind the supporting

pier. We [illegible] then make the projections rect[illegible]ular [illegible] the side arches and round beneath the ribs, thereby obtaining [illegible] arrangement, allied in form to the Transition style, the more readily if we make the crowns of the arches of equal or approximately equal height, which requires different heights for the springing points of the supports. The rectangular pier should be treated like a classic pilaster, but the semicircular piers supporting the ribs are not in any way to be considered as classic columns, their proportions being entirely distinct from those of columns; they are and remain round piers or vaulting-shafts.

There only remains the problem of reducing the section of the pier to a minimum, to occupy the least possible space and not obstruct the light. If the pier or the plan of its load be arranged symmetrically about two axes, it may be replaced by a simple symmetrical column, if its capital be so formed as to afford a proper support for each separate arch. If this symmetry exaist about a single axis only, the support may be a pair of equal or unequal coupled columns, or may consist of a group of round columns, Fig. 224, whenit is to be remembered that it is very difficult to transmit a uniform pressure, or one proportioned to the sectional areas of the different columns, ant that usually but one column supports the load, the others being slightly or not at all loaded. The round pillars require neither to be swelled, diminished, or fluted, not being columns in the sense of classic columns of fixed proportions, but are rather circular wall-masses. In all forms of piers heretofore cited, we have assumed the side arches and ribs to be separated above the capital, so that the section of the impost block is not composed of arch and rib sections intersecting each other. The reduction of the section of the pier to its minimum depends on the formation of the impost stone, neglecting the strength of the materials employed for the pier and the permissible crushing load on it. While the mode of executing a refined and complex piece of stone-cutting was not understood, the ribs and arches were necessarily separated from each other above the impost cap of the pier; it first became known in the best Gothic period how to allow arches to intersect at their lower ends, so as to require the smallest possible space on their support. Three cases then became possible; the extreme outer points of the ribs and arches were equidistant from the axis of the pier, or the arches, or else the ribs, projected more than the other members. F. 225.

The simplest arrangement for both appearance and execution is that where the ribs and arches unite above the impost to form a polygonal impost-block, Fig. 226, which shows the sect-

ion b reduced to its minimum. If the ribs are smaller than th the arches, the polygon has alternately equal sides c, and as each stone above the impost is to be wrought from a rough bl block of square plan, to save material, it is best to keep the number of courses between the impost and the lower voussoirs of the ribs and side arches as small as possible, and to allow the ribs to project so far from the axis of the pier, that their sections may completely fill up the upper square a b c d of the rough block, Fig. 227; the cap stone of the pier will then be square. If the ribs and arches are to project as littl as possible, to reduce the support to the absolute minimum, they should spring from a square capital as in Fig. 228; but if we wish to separately develop the arches, reducing the ribs only, the abacus of the capital might be square, Fig. 229. To place the most distant parts of the ribs further from the axis of the pier than those of the arches, would be incorrect; not forgetting the case where the ribs and arches have equal radii and equal heights of imposts and crowns in a vault on a square plan. A peculiar form of vaulted construction would then be developed, with very deep sections of ribs, cross-shaped and strongly projecting capitals, which should be treated as corbels, if they are to be placed on small supports; such constructions are suitable for mixed iron and stone construction.

Chapter 13. Entablatures of Stone, Wood or Iron.

1. The Treatment of Entablatures.

The bearing strength of entablatures increases in proportion to the square of their height and in direct proportion to their width; the spans of the intercolumniations then depend on the sectional area of the entablature, but chiefly on the resistance to transverse strain of the material employed.

The classic styles treated the architrave as a simple beam with a projecting margin, Fig. 230, or it was composed of two or three courses crowned by a cymatium, the courses separated by a beaded astragal or smaller cymas. The under side of the architrave was smooth or decorated by painted band-like patterns, but in Roman buildings it was generally ornamented by sunken panels, or band-like sculptures, Fig. 231, the latter commonly enclosed by cymas and beaded astragals. If the lower edge of the architrave appeared too broad, its centre was decorated by a moulded or ornamented band, and it was thus divided in two halves, Fig. 232. When the architrave was composed of two beams placed side by side, the under edge of each could be decorated by simple sunken or ornamental panels, or these moulded sunk panels could be symmetrically arranged about the central joint, Fig. 233.

Wooden beams have been treated fully in considering the construction of ceilings, and it only remains to briefly mention trussed beams or girders, which play an important part in bridge construction; whether of wood or iron lattice, suspension, or supported by piers, the supporting lower and upper members are connected by stiffening members and are so fastened together, that the girder becomes an inflexible whole, like a roof truss. Everything said of visible wooden and iron roof construction is also applicable to the construction of girders especially the general law, that in engineering construction on a large scale, the esthetic solution of the problem is to be sought in the plainest and clearest construction, and not in a paltry treatment of details. The recognition of the external appearance of a perfected construction as being esthetically valuable, is more important than any attempt to conceal the construction by covering the structural forms by decorations in thin metals or boards.

2. Entablatures of the Classic Orders.

Classic architects based the proportions of the intercolumniations and their heights on the lower diameter of the column and fixed certain normal proportions, that were more or less binding. Such normal ratios can evidently possess but a limited value, for the clear distance between the upper ends of the columns, or the actual span of the architrave, chiefly depends on the resistance of its material to transverse strain. Easily fractured marble required the columns to be closely set, tough stone permitting them to be widely spaced. Since classic columns had normal proportions of height, the Doric order c could have proportionally wide intercolumniations with low, but must have narrow ones with very high columns; for if the extreme limit of span of a stone beam were fixed at about 20 ft., the height of the order would depend on this span only within certain limits, and the character of the entire order might change without changing the actual span of the architrav

The Ionic and Corinthian orders, as well as those having pedestals, always appear to have proportionally narrow intercolumniations, their height being great in proportion to the lower diameter of the column.

3. Piers and Copings of Girder Bridges.

Piers of most girder bridges and of similar structures are usually strong wooden trestles, or masses of masonry, or are more rarely iron structures, that serve as the supports of the bridge girders. According to their arrangement, they are either abutment or intermediate piers; they consist of a base, the body of the pier, and the cap or coping for receiving the bridge girder, as they serve for piers of bridges across riv

ers or those of viaducts or aqueducts.

The base always serves as a firm and broad foundation for the entire structure, and bridges over rivers or arms of the sea must be so constructed with reference to the highest and lowest water levels, as well as the flow of the tides; it serves as a wave and ice-breaker, and has its peculiar form, adapted to the purpose, and may be provided with a coping, or may be prepared to receive the body of the pier by any suitable transitional form, the entire pier being diminished upwards, partly to save material, partly to prevent obstrution to the passage of the water, and in many cases to avoid loading the foundation too heavily; it also always looks better than if it were not diminished. The transition from the base to the body of the pier with its projections at sides and ends permits the most varied changes of section, that exert a pleasing influence on the form of the pier. Mediaeval architects well understood how to effectively treat these projections, which serve to break the force of the water, sometimes building chapels on them, sometimes furnishing them with platforms or balconies, accessible by steps, for giving aid to sailors or preventing logs from striking the pier.

The base of the bridge-pier and its projecting ends were not constructed with reference only to a pleasing effect, but to break the waves, to admit of the use of the plainest, rough, rock-faced ashlar, and the strongest mode of anchoring the stones together by iron cramps; when such pier-heads were protected by iron-work, they have a fine effect.

The body of the pier is often wanting, the girder being placed directly on the base, which is then crowned by battlements or a tower, a pedestal supporting a statue, a group of statues a through-pier which serves to conceal the junction of two bridge-girders; the body of the pier sometimes rises from its base, leaving a bold offset as an abutment for the struts of a wooden abutment bridge, Fig. 237.

The coping beneath the bridge girder serves as a block for its support and as a cap for the pier. It should have a strong projection where it receives the girder, for the first; for the latter, it must have a bold cornice, Fig. 238, profiled in various ways, according to the character and arrangement of the bridge.

The corbellings at the top of the pier, angle projections, tower-like additions, towers, and other structural motives for developing the architecture should be used when possible, in order to make a truly architectural work of the simplest and most economical problem of bridg construction.

The abutments at the ends of the bridge might receive a rich

r ..d more pleasing architectural treatment with known archi-
- tural motives, than is usually accorded to them. They are
.ually only terminating masses of masonry, to resist the pres
ure of the earth, such as retaining walls, their external ap-
earance being principally dependent on the kind of masonry.
special emphasis should be laid on a transision between the
butment and the bridge girder, because the unpleasing junct-
on of the girder and pier is generally neglected. Corbelling
s a valuable esthetic expedient, and the hard intersections
f horizontal and vertical lines at the end of the bridge
hould be broken by flights of steps, Fig. 240, pendentive
aults in the angles with the side walls, Fig. 241. angle tow-
rs, Fig. 242, buttresses, and similar motives. This hardness
isappears in arched bridges, whether built of masonry or mere
y bridge girders of curved form.

Chapter 14. Arches Above Piers and Columns.

1. General.

Fixed rules for proportions of arcades cannot be given with
out regard to the purpose for which they are employed; the ef-
ect of the arch will be the more powerful, the greater its
adius, and the smaller the height of its abutment, Fig. 243;
t will appear heavily loaded and weak if the arch be too thin
ightly loaded and clumsy if it be too thick, Figs. 244, 245.
he form of the arch has to us something peculiarly character-
stic through associated ideas; segmental and elliptical arche
s of low rise seem to be depressed, Fig. 246, and this charca-
er of depression corresponds fully to the arrangement, where
the supports of the arch are low, as in low halls or bridges;
it is more or less opposed to use for rooms of considerable
height and to spans on high supports; the depressed arch, whet
her segmental or elliptical, only looks well as a discharging
arch, when the arch merely serves its purpose without raising
the question of its pleasing appearance, Fig. 247. Its stabil-
ity is increased and its appearance becomes more pleasing, if
its depth be increased towards the abutments, Fig. 248. The
elliptical arch of low rise is fully justified when of small
s, an between abutments, which serve as corbels, Fig. 249. The
abutments may then be replaced by supports or corbels of dif-
fe nt forms, which likewise support the elliptical arch, Fig.
250. The broken segmatal arch may often be used, Fig. 251, but
... strictly only a pointed arch; the broken oval arch may
.e . very elegant effect at other times, as it surpasses seg
tal and elliptical arches in pleasing effect, if its rise
1-3 its span or 1-2 if its cruvature be as regular as poss
. semi .rcul.. arch always appears pleasing if its lower

ends are not concealed by a projecting impost cornice; it suits any proportion between its span and the height of its supports; it may spring directly from a footing, its piers being omitted, or it may be placed on very high supports, without producing a disturbing effect, though a pointed arch is more pleasing in the case; it may be strongly stilted if necessary, so that it is usually better suited to all cases than any other form of arch.

The pointed arch is least adapted to the case, when the vertical direction is to be especially accented. Various structural methods for determining the radius of the pointed arch were known in the Middle Ages. 1, The radius is 2-3, 3-4, 4-5, or n-(n + 1) times the span, Fig. 252. 2, The radius is the hypothenuse of a triangle, whose sides are to each other as 1 : 1, 1 : 2, 1 : 3, or 1 : n. 3, The centres of the arch are found by projecting the angles of the polygon on a diagonal, Fig. 253! 4, The centres are found on a diagonal of the polygon, the pointed arch passing through two or three angles of this polygon, Fig. 254. All these methods have the sole purpose of aiding the enlargement of the pointed arch to full size and obtaining exact work in stone cutting; some possesed special advantages in the construction of forms of tracery, while others were but trifles. It would be well practically to fix the centres of the parts of the arch, pointed or oval, by some definite rules, to lessen the labor of drawing them full size. Compare constructions of Fig. 254 a. All kinds of combined arch forms , Fig. 255, like those preferred in mediaeval and Mohammedan architecture, in Netherlandish Renaissance, and especially those composed of concave and convex curves, have no structural but only a decorative value, and should therefore be excluded from structural designs when possible, being left to the domain of decoration, where they are justifiable. Thus small doors or windows, cellar openings, narrow openings in walls, covered by a single stone, also small canopies or coverings of niches in walls, may well be finished by arched forms, combined in the most varied ways, while the same forms would not be structural, when used on a large scale, and should be avoided on that account.

The segmental arch requires an increased depth towards the abutments to increase its stability under a greater load; but the pointed arch requires this increase towards its crown, Fig 256. To a knowledge of this fact, we owe the feeling of repos arising from an assurance of a correct mode of construction, in seeing one of these two cases; such repose would scarcely be felt by one ignorant of this, since the associations of the ideas here considered would then be wanting to him. An arch

of low rise can support only a proportionally light load, but a pointed arch can support a heavy one; hence, on an association of ideas is based the visible need for a flat arch to appear lightly loaded, and a pointed one heavily loaded at the centre. When attention is not paid to these considerations unpleasing effects are produced.

It is generally true of forms of section of arches, as stated for side-arches, that the profile of the archivolt may change its character, Fig. 257; 1, according to the depth of the arch;, 2, according to the projection of the arch from the face of the wall; 3, according to the desired inclination of the spalyed surface for affording admission to light and touching the extreme projections of the profile.

2. Arched Bridges.

Arched stone bridges require the impost block to be made clearly prominent by a horizontal incision and a clear treatment of its abutment.

The impost of the arch will often also be the coping of the pier, or if the pier be wanting and it coincides with the base the coping itself forms the impost; the arch otherwise springs driectly from the foundation of the bridge, making an impost cornice unnecessary; For reasons of stability, the lower part of the arch should be built with horizontal courses for about half the rise of a semicircular arch, or rather more in a flat elliptical arch, and about one-third that of a pointed arch; that is, a wall-mass gradually widens upwards and is formed by corbelling out the separate courses of stone, and the arch pr presses against this as an abutment. This abutment mass shoud should differ from the arch itself in material and structure, and may be made especially prominent, Fig. 258. At the same time, the principle of economy will generally require, that to characterize the abutment, it must be dressed smooth, if the arch is built of rock-faced ashlar, or that it be marked by bordering members, coats of arms, emblems and other decorative expedients, if the arches are dressed smooth in city bridges.

The segmental arch always requires a skew-back normal to its curve, and has a bad effect if it abuts directly against the coping of a support, Fig. 259; if the arch is not bordered by mouldedm members, it does not appear more ugly, than if those borders are composed of horizontal headers, or abut against each other, unless the intersection is especially supported by a corbel. The first radial joint of the segmental arch separates it from the skew-back, wrought from a single block or in horizontal courses, and may be marked by a boldly profiled inserted slab; the skew-back itself may be formed as a corbel in small bridges, Fig. 260.

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If the separate bridge arches spring from separate skew backs, or the piers are of unequal width, a small arch may be inserted between the ends of the main arches to save material; this occurs in the Ponte de Quattro Capi, Rome; the end piers may also be broken by gateways, or outlet openings may be le left above the abutments to carry off water from bridge way.

If girders of wood or iron in form of arches be combined with piers of masonry, the piers should have proper abutments for the girders, and these should generally be skew-backs, coinciding with the radius of the arch at the joint.

3. Covered Bridges, or with Buildings.

If the bridge is covered by a roof, the structural ideas result from the arrangement of its supports, and of the bridge piers on which it rests; to not load thebridge too heavily, the construction of the roof should be as light as possible, and the spans between the supports as great as possible; these rules disappear at the piers themselves, where a grouped arrangement of columns is desirable. From this idea results the arrangement of pavilions, twoers and portals on the piers of the bridge, and open halls over the bridge way, such arrangements being carried out in the most baried ways in the few existing examples.

Chapter 15. Buttresses and Flying Buttresses.

Buttresses are either increased thicknesses of walls to prevent their yielding, or to resist the thrust of vaults; their nature is identical in both cases, as a wall can only yield sidewise to a force acting in that direction, at an angle with the wall; it is immaterial whether this force is produced by a vault or not. The buttress Fig. 261 must always be arranged in the same direction as the force, whether perpendicular or oblique to the wall; if two or more forces act on the wall, so many buttresses must be arranged, one opposed to each force, or, as the forcesmay be combined in a single resultant, a single buttress may oppose this resultant force. The force acting against a wall may be distributed over its entire surface, as an earth pressure, or it may act at one or more points; it would tend to slide the entire wall sidewise in the first case in the second, to overthrow the wall or bend it.

If two or more forces act against a wall, the construction of a buttress simply consists in connecting the points of ap-application of the forces by a rigid body, then applying to this body a force having the same line of action and magnitude as the resultant of all the forces it equilibrates.

The force F, Fig. 262, sufficient to move the wall sidewise, is proportional to the weight P of the wall, i.e, to the pressure

sure it exerts on its foundation, and to the coefficient of friction f of the materials of the wall and foundation on each other; thus, F -- P X f, P -- F-:- f, f -- F-:- P; the area and form of the bearing surface not being considered. The more firm, solid and heavy the masonry, and the rougher the bearing surface, the less danger of sliding of the wall.

As for overthrow of the wall by the force k, this force is proportional to the weight g acting at the centre of gravity of the wall, to the distance x of the horizontal projection of the centre of gravity from the point of rotation C, and inversely proportional to theperpendicular a let fall from the point of rotation C to the line of action of the force k; or, expressed in a formula, k -- g x -:- a. This shows that the wall will be the more stable, the greater its weight, its thickness and the lower the point of application of the force k, or the greater the angle of inclination of the force, and k has no injurious effect when C is a maximum, the weight and thickness of the wall being infinity, or the point of application coincides with the point of rotation.

The weight C and distance a being constant, x may be increased, Fig. 264, and theentire mass of the wall may be so arranged that its centre of gravity falls as near its inner side as possible by increasing its height or making it externally battering. The wall becomes more stable by battering it, or building it in offsets, Fig. 265. When x -- b, a maximum is reached, but that would only occur if the wall is corbelledout so much on the inside that its mass is bisected by vertical A.

A buttress is only a wall-mass, safe by its conditions of stability; its effectiveness thus increasing with; 1, its projection at its base; 2, its load or the use of heavy building stone and increase in height; 3, by corbelling it out on the inside. The point of application of the force k and its line of action are almost always given; if the buttress is arrang d to resist the thrust of a vault, the point of application of this force k is found at the intersection of the tangent of the central line of pressure with a vertical through the centre of gravity; Fig. 266; the tangent K is the line of pressure itself at this point. The weight C of the wall and buttress combines there with the thrust, forming a resultant, which must lie wholly within the buttress. Thus, if the stability of the buttress and wall is to be increased with economy of material: 1, the point of application must be kept low; 2, the line of action of the force must be steeply inclined; 3, the projection of the base of the buttress is to be small.

The first condition is satisfied by having the springing point as low as possible; the second gives the buttress as ... weight as possible.

great weight as possible and corbels the construction towards the interior, to incline the axis of the masonry inward, drawn through the centre of gravity; the third is satisfied by the projection of a part of the buttress on the interior, and by a reduction of its mass, if permitted by the line of pressure. Fig. 267. Openings are therefore admissible at the base of the buttress, as well as above the line of pressure. From what has been said, the projection of the buttress should be greater than its width, its stability increasing more with increased projection, a heavier load, and corbelling out on the inner side, than by increased width.

The esthetic ground-ideas for the formation of buttresses are as follows: the buttress requires a considerable projection at its base; as a wall-pilaster, regarded as an addition at right angles to the wall for strengthening it, the thickness of the buttress must at least equal that of the wall, or it will seem too weak. Openings for doorways are permissible in its lower portion, and the base of the building must be broken around it. The offsets in breadth or thickness should be capped by simple inclined planes, large or small, according to the arrangement of the whole, and which may be covered by inclined or gabled stones to shed rain water, Fig. 267. If this inclined surface be large, it may properly terminate in a gutter with a lower opening for discharge of the water, affording opportunity for decorative ornament. In strongly projecting buttresses, a string-course at the lower ends of the windows, and also a gallery, wil sometimes be desirable, forming a passage around the building with openings through the buttresses, or broken around them. Fig. 268.

The separate offsets of the buttress may be treated as free-ending masses with light decorative ornaments. The leading ideas for the upper end of the buttress are as follows: it is either terminated beneath the main cornice by an inclined plane, or a free-ending piece of decorative work; or it is connected with the main cornice, the whole of this or merely its upper or lower members being broken around the buttress, Fig. 269; or it interrupts the main cornice, which abuts against either side of the buttress, Fig. 269. In the last case, it may be terminated by heavy masses, for which two ground-ideas are applicable. This load either consists of a figure, or the pinnacle takes the form of a stone pier, battered or diminishing in pyramidal form; the motive of groups of figures is preferably that of the Renaissance, that of a pyramidal mass of stone being Gothic; instead of the last, obelisks are employed in the late Renaissance, after the precedent of the Tomb at Albano.

The most effective means for loading the upper part of the buttress always consists in corbelling out the main cornice above arches, which throw on the buttress the entire weight of the mass between two buttresses, Fig. 270; a still heavier loading is provided by a kind of attic story erected above the main cornice and constructed of simple arches spanning the space between two buttresses, Fig. 271. The arches might be utilized as openings for the admission of light to the attic of the building, also being windows in a small corridor or in small chambers in the roof. The Gothic indeed introduced gable dormers for this purpose of loading the buttresses on a similar principle.

If the buttresses are arranged within a building, it may happen that they require to appear externally as low buttresses of moderate projection, Fig. 272; these may terminate at top in any suitable manner without the necessity of vertically dividing the upper wall of a building of several stories; or they may perhaps require a very strong projection, according to the arrangement of the vault, so that by vaulting over the spaces between buttresses, external galleries may be formed above deep recesses or above a row of internal chapels, Fig. 273.

As the breadth of the buttress is diminished by offsets, there may also be offsets in its thickness, though these can only be small, on account of the small thickness of the buttress, Fig. 274; (side offsets are not used in buildings in the U.S., though the base courses of the building are generally broken around the buttresses, but not string-courses.)

Groups of buttresses are always required at the angles of vaulted rooms and buildings, and for towers, and are sometimes employed in connection with angle towers of staircases. The usual arrangements are the following, Fig. 276: the buttress is set back from the angle at a; directly at the angle as at b; or diagonally at c; the corresponding arrangements of a staircase tower would be as at a', b' and c', this tower being one of the most appropriate expendients for strengthening the angle, as well as frequently playing an important part as a servants' staircase. The group may combine in a mass at their bases and separate above this, Fig. 277; by the use of diagonal members peculiar arrangements of piers are obtained, as in the treatment of buttresses in the Gothic style, memorial columns and similar forms of piers.

Buttresses are not a monopoly of Gothic, or suited to that alone, nor must they always be treated with Gothic forms; they are a general result of vaulted construction, and in problems like those solved in the Middle Ages, we cannot dispense with the buttress. But if we wish to give to it a Renaissance form

entirely neglecting the existence of the Gothic style, we should to a certain extent return to the forms devised by the Middle Ages; the generally accepted aprt of mediaeval architecture is this, that it created forms, which cannot be replaced by any better ones. To exclude these on principle would be to progress backward. Conversely, we must never feel constrained to retain the detal forms of Gothic, used for buttresses and flyingbbuttresses, because no others were used. We should avoid the use of buttresses as purely decorative, which also occurred in Gothic, when nothing is to be resisted, but must certainly not fall into the opposite error in Renaissance, of greatly enlarging the volutes of modillions intended for a small scale, and of employing them as meaningless forms for buttresses, as general form-symbols for the indication of a horizontal thrust.

Flying buttresses are arches, which transmit the thrusts of vaults to the mass of a buttress, not by a heavy and inflexibl buttress pier, but by an arch, itself exerting a thrust. They become necessary in all basilican designs of several aisles, and may also be used when buttresses are entirely omitted, but fixed points exist, like rocks, massive walls, etc., to which the thrust of a vault may be transmitted. They lose their function as arches exerting thrusts if free-standing piers, or the angle masses of towers, are connected with the principal mass of a building by oblique struts, or by horizontal bridges which they support.

The following arrangements are possible:

a. Three or four-aisled basilican structures.

1. But one buttress is required. 2, Two separate buttresses are necessary, Fig. 278. 3, To increase the resistance, two flying buttresses are used, connected together, Fig. 279. 4, But one flying buttress is necessary, though this must be very heavily loaded.

b. Five or six-aisled basilican structures.

1. Side-aisles in pairs of different heights. Two flying buttresses are then arranged above each side aisle, as in the Cathedral of Beauvais, Fig. 280, or a single flying buttress spans the outer aisle, a second and larger one being thrown over both side aisles to the centre aisle, as in the Cathedral of Notre Dame at Paris, Fig. 281. 2, Side aisles of equal height, when the inner aisle requires two, and the outer aisle one flying buttress, Fig. 282.

The buttress-mass, agains which the flying buttresses abut, must satisfy the conditions previously given, but it is particularly necessary to locate its centre of gravity nearest its inner side by corbelling out the masses.

Flying buttresses are to be regarded as arches, and are to be treated accordingly; they will be more stable if in the f form of half a pointed arch, than if quadrants; with very high centre aisles, like those of larger Gothic cathedrals, they must not only resist the thrust of the vaults, but also hinder the vibrations of the centre aisle caused by violent storms. In such great structures, it may happen that the total mass of the buttresses and the flying buttresses presents so large a surface to the action of the wind, that they require to be con nected by transverse arches. If such a case occurs, the build ing itself would be concealed by a formal scaffolding of buttresses and arches.

If the wall-mass of the buttress is to be decorated, one must distinguish between those points, which may be made lighter by perforations or openings, without injury to their structural meaning, and those, which may be merely decorated by niches containing figures, canopies, inlaid panels, etc. To utilize the upper edges of the flying buttress as channels for rain water, as in Gothic, will seldom be repeated, not being a very practical procedure.

A buttress can fulfil its purpose of strengthening the wall only when the masonry is well bonded together; hence it could scarcely be constructed of Cyclopean masonry or boulders. A good bond can only be had with rubble of quarried stone, ashlar masonry or brick masonry; bonding of ashlar masonry would be strongest if blocks cut with reentrant angles were used, Fig. 283 a. For a wall about 3 ft. thick, an ashlar about 2 ft long and 1 ft. wide, a buttress projecting 3 ft. and of equal width, would be well bonded as shown in Fig. 283 b. If buttresses are in brick masonry, all offsets diminishing upwards must diminish by courses.

Chapter 16. Openings in Walls.

Openings in walls are I, in walls of masonry; II, in those of wood or iron. Their purpose is either the admission of light, when they are windows, or for passage, when they are doors and gateways. To the latter may be added portals of tunnels, gateway bridges, openings for passage of water, etc.

The leading idea for the treatment of openings in walls is based on the construction of the wall, a portion of which is removed by the opening, interrupting the bond in one place; the adjustment of the bond depends first on the clear width of the opening. The treatment of the opening is also arranged to accord with the thickness of the wall, and the quantity of light to be admitted to the room, or for doors, to the desired ease of passage. The treatment of openings in walls is further de-

dependent on the mode of closing doors and windows, also on the form of raised members and borders.

1. Openings in Walls of Masonry.

We will first examine a few problems commonly occurring in openings in walls, before considering details of doors and windows.

a. General.

1. Spans of Openings in Walls and their Bond.

The simplest mode of covering narrow openings in masonry walls will be by a single ashlar; this may be cut out in various ways, Fig. 284; but it would thereby be weakened, and fracture at its centre is to be feared. Fracture of a simple ashlar will less readily occur, if wrought from a very hard material, or if raised at its centre, as in Fig. 284, 5; a hollowed-out stone will not be so easily broken if it be formed as a keystone, as Fig. 285, or if a joint be arranged beforehand where it threatens to break. Whether hollowed-out or not, a stone may be protected against fracture by its load being otherwise supported, in the simplest way by two blocks, Fig. 285; This may be most perfectly accomplished by three voussoirs, acting as an arch, Fig. 286. The same end may often be attained by allowing a keystone to extend through two courses, Fig. 286. Or three voussoirs may be so joined that their lower surfaces form a plane. These and other modes of covering narrow openings are especially employed in cellar windows; the arched form of the covering stones may usually be chosen at pleasure, permitting the use of the most diverse forms, Fig. 287, it being scarcely necessary to consider more than the decorative effect of the arrangement.

As for the bond of these simpler constructions of openings in walls, the following motives would result from previously treated ground-laws for bonds, it being assumed that the construction of the covering and jambs is to be in cut stone.

1. In masonry of boulders and rubble, the stones may have irregular and inclined end-joints, these kinds of masonry being better suited for random joints than vertical ones., Fig. 288.

2. In polygonal and Cyclopean masonry, one must seek for a suitable covering stone with horizontal under surface, or to arrange three such stones with radial joints, Fig. 289; also to arrange the jamb stones to form regular jambs, whether vertical in rectangular, or inclined in trapezoidal openings. An interesting example of a small window with bond suited for Cyclopean masonry is here given, from the choir of the Cathedral at Treves, Fig. 290, of the end of the 12 th century.

3. In irregular masonry, mostly composed of blocks with reentrant angles, Fig. 7 being an example of this from Greece, the

most varied modes of covering the openings become possible, and the joints and possible protecting bosses give rise to peculiar forms. Such arrangements are entirely pleasing and proper for the fortress-like character of many buildings, if not too affected, as in the windows of the new Palace in Baden-Baden. Fig. 291.

4. In mixed kinds of masonry, partly built of quarried stone and partly of brick, or of stones from river beds in barley-ear bond, the openings should usually be covered by ashlars, against which the bond abuts, or by arches, agains whose top the bond abuts as may chance. Beautiful examples of such mixed masonry of the Roman period, as well as mediaeval, are shown in the illustrations from the Imperial Palace at Treves, and from a buttress of the Nicolai Church in Bautzen, Figs. 292, 293; 294. In the first, the masonry below the springing is built of alternations of 3 courses of bricks and 3 of quarried rubble; the bricks of the arches are not trapezoidal, but merely thin bricks; the quarried stones are roughly dressed, though not as ashlars. The bricks are 13 3-8 in. long by 1 9-16 in. thick, and the joints are as thick as the bricks. The largest tile in the arch is 21 5-8 in. square by 2 3-4 in. thick The dressed stones are 5 1-2 in. thick and 7 1-8 to 8 11-16 in. broad. In the last, Fig. 294, larger blocks of granite alternate as voussoirs with smaller fragments, and the masonry is composed of quite irregular granite rubble, the angles being strengthened by larger regularly dressed blocks of granite.

Opus reticulatum is seldom otherwise used than in combination with regular arches of brick or stone, against which it abuts as may happen.

5. In peculiar kinds of ashlar masonry, like that previously described from a church in Naples and the fortress in Florence, simple and narrow openings were formed, covered by a single voussoir.

6. We have already considered in general openings in ashlar masonry for small spans, as in cellar windows and small openings of all kinds for admission of light. In wider openings, there is to be especially considered their covering by arches, (segmental, elliptical, semicircular and pointed), as well as jointing these arches in connection with the bond of the masonry. To not weaken the crown of the arch, the extrados is either parallel to the intrados, or the voussoirs are so arranged with the coursed bond, that the keystone may have the required height. If the arch consists of but 3, 5 or 7 stones it will not be very difficult to bond them with the ashlar masonry, as the arch will scarcely affect more than 4 courses in height. For practical reasons, the divisions of the voussoirs must be so

must be so chosen as to be suited to the natural thickness of layers of the stone, at most 15 3-4 to 23 5-8 in. thick; for stability, it is preferable to compose the arch of as many voussoirs as possible. It would therefore be well to base the division of the arch on the least thickness of layer of the stone, since the voussoir must be thicker at its outer edge than on the intrados, and to divide the intrados into as many stones, including the keystone, as the space permits; since for stability, it is preferable to lessen the span of the arch by corbelling out the abutment, and the division of the arch may vary within tolerably distant limits.

The division of the arch into voussoirs and of the wall into courses will collide if one division be not made dependent on the other. In the division of the courses and voussoirs, the following cases are possible: a, courses of equal height; b, heights of courses alternately equal; c, the courses of unequal heights; d, voussoirs of equal breadth; e, breadths of voussoirs alternately equal; f, their widths unequal.

Since the construction entirely depends on the form and clea clear span of the arch above the opening, each separate case leads to a special mode of division; it is sufficient to remember here that strongly loaded segmental arches should have their depths increased towards their abutments, Fig. 295 a, and high arches towards their crowns, Fig. 295 b; at the same time when breadths of voussoirs are unequal, they should be wider towards the crown than towards the abutments.

The jointing of arches of wide span, or the covering of narrow openings, is always to be arranged in accordance with the height of the courses of the material, if the wall is built of brick; if the arch itself be of brick, it should always be constructed of voussoirs, of bricks cut or pressed to that form, or the bricks retain their rectangular form, and the mortar joints between them are wedge-shaped. But it will in all cases be most proper to make the extrados of brick arches parallel to their intrados, for it is always best in brick construction to employ a normal form of brick throughout; wedge-shaped mortar joints are preferable to trapezoidal bricks (?), and to dress off the outer ends of the bricks, to unite well with the bond, would not only be formal, but also useless. (Wedge-shaped mortar joints ought to be avoided; otherwise, the middle of the joint should be pinned or filled with slate, then pointed on each face)

If a brick arch be not concentric but has a stepped extrados as in ashlar masonry, Fig. 296, this may be done in two ways; either by horizontal and vertical, or horiozntal and radial limiting joints; but this arrangement would possess no great

structural value, particularly in the second case, as the bricks would have to be cut and rubbed to voussoir shapes, but would often be justified by decorative reasons; one would scarcely increase the depth of a pointed brick arch towards its crown, or of a segmental brick arch towards its ends, for small spans, Fig. 297 a, since cutting the separate bricks would make the strength of the arch doubtful, and to offset the bricks would make the arch appear ugly. To construct the arch of several concentric rings (in rowlocks) is structurally meaningless, since only a strengthened arch with radial joints extending through its entire depth would only appear, but also really act as such. Roman arches, composed of several rows of bricks, owe their strength only to the excellence of the mortar, not to their construction. (Arches in rowlocks are often preferable, not requiring as strong centres and being also less liable to crack from settlement of the piers).

8. The arch may first be decorated by alternating the building materials employed, as in brick masonry, voussoirs may be inserted between the bricks of the arch. A second motive for decorating the arch consists in accenting its principal points its crown, springing points, and the location of the joints of rupture, Fig. 297 b; the brick construction of the Dutch Renaissance is charcaterized in this way, keystones, springing stones and stones at the joints of rupture being placed in arches of the most different kinds, the remainder of the arch being entirely of brick.

Not only Dutch, but also Italian Renaissance, sought to relieve arched construction by accenting the springing points, joints of rupture, and crown, especially in doorways of simple houses and also in simple plastered dwellings, whose plainness required the invention of original motives. A few examples of such motives for doors of houses from Como, Bergamo, Bellagio, and Brescia, may find place here, Figs. 298, 299, 300. The latter is more characteristic than beautiful or worthy of imitation; all the joints of the splayed soffit and jambs radiate from a single point at the height of the eye. But with exception of those marked f, these joints are not real but sham ones. This sham architecture cannot be considered otherwise than as objectionable.

A motive suitable for ordinary plastered masonry consists in covering the real discharging arch over door or window openings by a slab of vtone placed before it, which may have a moulded edge, or be decorated by foliage; the key and springing stones, as well as the stones at the joints of rupture, may then each be developed in its own way. The springing stone is always an accented point, and its treatment may follow the

most diverse modes; foliage, heads, shields of arms, etc., are suitable for its characterization. The keystone is the most important point in arched construction and requires special accenting; it also often serves for the most varied purposes, and may therefore be formed as a corbel supporting a projecting cornice, sometimes supporting a bust, a shield of arms, or one bearing the number of the building. The noblest decoration of a keystone will always be a human head; symbolic emblems, heads of animals, etc., may be substituted for this, according to the purpose and importance of the building.

2. 2. 2. 2. Thickness of the Wall, and Light and Space-giving Character of Doors and Windows.

Openings in external walls are intended for admission of light to a room or to give access to men or animals. Even embrasures, whose direct purpose is to permit the passage of a projectile, are always to be considered as openings for light, since they must be so arranged that the object may be seen through them, at which the projectile is aimed. In arranging openings in walls, the leading idea in windows is the admissin of light; in doors to facilitate access; the opening should then be made wider either externally or internally; an external widening is necessary or proper for doors used by large numbers of persons, and those windows which are not to be looked through from within, as in raised church windows; an internal widening is desirable or necessary in many doors, when a room is to be quickly emptied of people, as in theatre and church doors, also for windows intended for observation, like those of dwellings and many public buildings.

A further basis for the determination whether an opening in a wall should be enlarged externally or internally, is the way in which the doors or sash are to open; if these are not folding, the opening must in many cases be splayed inside, that the door does not project beyond the jamb, Fig. 301; if folding the splayed jamb need not be so wide and the opening may also be splayed externally. If the door or sash be required to entirely fit into the splayed jamb, pilasters projecting inside will sometimes be necessary, Fig. 302; their projection beyond the inner face of the wall may be considerable, if the wall be not sufficiently thick to receive the entire door or sash, that this may not project beyond its inner surface.

Conversely, in doors, the doorway may project beyond the external face of the wall, both for facilitating passage and affording a projecting shelter, thus making the opening in the wall deeper than could be obtained within the thickness of the wall alone. This arrangement may be necessary at entrances of churches, palaces, city halls, and similar buildings for pub-

lic assemblies.

3. Consideration of Means of closing Doors and Windows.

In all openings in walls intended to be temporarily opened or closed, this requirement will aid in determining their arrangement and plan. Rectangular doors and windows are always preferable for the rooms of dwellings, on account of the admission of light, the joinery, ease of opening and closing, and the fixing of curtains before the opening, usually spanned by a segmental or semicircular arch. In public buildings, which require larger doors and windows on account of the depth of the room to be lighted and the greater number of persons, the doors and windows require to be round-headed, or the windows must be divided by mullions if they have considerable breadth; windows seldom or never opened, by the aid of special mechanism, or only in part for the sake of ventilation, like those of churches and buildings for ordinary purposes of all kinds, are less dependent on the form used for spanning the opening. It is generally unnecessary and inexpedient to make the doors pointed at top, Fig. 304, even if the pointed is the predominating form of arch in the building; it is one of the most common faults of architects, ignorant of the spirit of Gothic, to believe it necessary to make the doors pointed because the windows are so. Gothic seldom made doors pointed, the discharging arch was generally pointed, but the door was terminated by a straight lintel or one cut to a segmental curve; if the door be made pointed, Fig. 304, the internal opening must commonly be spanned by a segmental arch, since the door could not be opened if a parallel pointed arch were used, covering the opening by a pointed tunnel vault.

4. Limiting Forms of the Material next the Opening as Projections, Borders and Splays.

The construction of these openings determines the choice of the sections of their architraves. Let a b, Fig. 305, be the direction of a ray of light passing through an opening enlarged externally, and let c be a parallel ashlar of the wall; the entire enlargement of the opening may be so moulded that the splay a b forms the limit of the moulding. The entire space from c to d, Fig. 305 b may also be replaced by a border-profile, to make the architrave still braoder than before; the parallel ashlars and their margins may also be moved forward to the point e, Fig. 305 c, leaving the splay c d, or this may be replaced by a moulding; in the two first, the total breadth of c d of the profile is greater than in the third; the enlargement of the opening is equal in the first and last, but the breadths of the profiles are different. According to the principle of treating the openings, we have free choice how

wide to make the architrave and how much to splay the opening. The principle of this kind of architrave is based on the assumption that the opening in the wall is formed by omission, when the same bond is employed for the entire wall, whether stone or brick; or in other kinds of masonry, the opening is enclosed by a layer of ashlars or bricks, Fig. 306. The second structural principle, determining the choice of profile of an opening in a wall, consists in enclosing the opening by a special architrave, against which the masonry abuts, Fig. 307. This masonry may be ashlar, Cyclopean, rubble, brick, or of any other kind, while the architrave is stone or brick.

By the wall-face is always understood the real or ideal vertical plane from which the panelled ashlars project, and which coincides with the faces of those with triangular joints, in accordance with the first principle of the construction of openings in walls, the profile of the architrave is always behind the wall-face, but may project in front of this in accordance with the second principle; both principles must always be kept distinct and never combined, so as to have the architrave project in front of the face of the wall, unless it be structurally separate, for toherwise surplus stone must be dressed off each block of the architrave.

In very thick walls, the openings have very wide jambs, that may be constructed of ashlars, either as shown in plan at a and b, Fig. 308, where the spaly is produced by stones set obliquely, or in accordance with the plan c and d, Fig. 309, where the spalys are produced by rectangular offsets; the examples b and d represent the architrave as projecting considerably in front of the wall-face. In case d the rectangular offsets may be replaced by small columns in windows and entrances or the angles between the offsets may be filled by small columns, Fig. 310, these capitals supporting arches profiled in any manner.

b. Special on Doors, Windows, Gateways, etc.

Openings in walls are openings for admission of light, as windows, or they are passages of all kinds, as doors, gateways tunnel portals, gateway bridges, openings for discharge of water, embrasures, openings for ventilation, etc. Windows are formed in vertical walls, either with a vertical axis, or are wheel-windows, in which is included all windows arranged about a centre, or are in ceilings, as skylights. According to ther uses, windows principally belong to dwellings, public buildings and palaces, or to curches. We shall describe openings in walls in the following order: 1, windows of dwellings; 2, windows of public buildings and palaces; 3, windows of churches; 4, wheel-windows; 5, tracery of windows; 6, skylights;

7, doors; 8, larger gateways, including city gates, fortress gates, triumphal arches; 9, tunnel portals; 11, gateway bridges; 12, openings for discharge of water, for ventilation, embrasures, etc.

1. Windows of Houses.

First consider windows of dwellings, because the most important separate motives may be deduced from these as being normal arrangements. Windows of very plain buildings and of thos merely intended for useful purposes, will take the simpler forms already treated. The problem is always to obtain the best effect with the simplest means.

a. Cellar Windows.

Their proportions change in each case. From their low heig they are made as broad as possible, if the admission of consi erable light is desired, and are then either grouped in twos, threes, etc., splayed inside, spanned by a proportionally low horizontal lintel, which may be omitted when the water table itself forms the lintel, Fig. 311. The profile of the architrave may be entirely omitted, or be simply treated, so forme as to admit as much light as possible, with an external rebat if wooden cellar sash are necessary, or if the windows are fi ed, with an internal rebate, which may be omitted if the wooden frame of the window fits into a rebate in the stone, Fig. 312. If the windows of the cellar story only serve to light rooms in the cellar, they are generally made subordinate, but the most varied combinations with the ashlar masonry of the substructure are admissible, like those mentioned in treating the simpler methods of covering small openings in walls. Special arrangements result from combining the windows of the ba basement story with those of the cellar.

b. Windows in the Basement Story.

The forms of windows in the basement or lower story are always suited to their arrangement. The basement of a house fo renting will contain smaller and therefore less respectable dwellings, than those in the first story, the doorway and entrance hall occupying part of its space, or it will be taken for a small shop.

In detached houses and villas, the basement usually contain the reception rooms, dining room, etc., thereby becoming the principal story, while the upper story becomes subordinate an contains the bed-rooms, breakfast room, nursery, boudoir, etc if a second or third story is found in city houses for rentin these stories also contain subordinate dwellings. The charac ter of the stories must be indicated by the architecture, but at the same time in the taller houses, the basement story forms the base of the entire building, and the upper story is

its termination, and since it expresses the natural feeling, that the upper part should be light and the lower heavier, a change must be made in the windows of the different stories, both in dimensions and in treatment.

c. Architraves of Windows.

The architraves, like most moulded portions, are often worked from common stair-step blocks, where made possible by a great development of the business of quarrying stone, as in Dresden; the rough blocks have normal dimensions of 7 1-2 to 8 in. wide, and the profile of the architrave varies in width from 6 to 7 in.; yet the same width of architrave is retained in different stories, though this width may be increased from the least to the greatest measure, according to the richness of the profile and of the entire building, and also according to the elegance or simplicity of its character.

Since the clear width of the windows of different stories vary, while the widths of their architraves retain a normal width of about 6 1-2 in., the proportion of this to the clear width of the window varies from 1-7 to 1-9; consequently the architraves of narrow windows appear broad, while those of wide ones seem narrow. Dimensions in Dresden are in general to be termed small, owing to the fine-grained sandstone used there; architraves of classic and Renaissance windows are generally wider, from 1-4 to 1-6 the clear width.

We have so far considered the window and its architrave as it appears normally in houses with smooth plastered or stone walls, and where the architrave is not produced by spalying the angles of the opening, but by the separate lintel and jambs of the window. The projection of the jamb-stones in front of the face of the wall must at least be 9-10 in. for plain or 1 3-8 in. for moulded jambs, to make its effect seem satisfactory; other practical dimensions are given in Fig. 313.

The Dresden school has fixed the following normal profiles for the architraves of windows, for the most varied cases occurring in practice, all having strictly a Renaissance character, and being adapted to the Pirna sandstone used, though leaving the proportions of the details to the esthetic sense. (The numbers refer to the different types of section of architrave).

1. For smaller windows, Fig. 314, of simple character, 6 in. wide and 9-10 in. projection.

2. For smaller windows of richer character, same width and projection, Fig. 315; the sunken panels may have corners filled with rosettes or by delicate ornaments in very rich arrangmts.

3. to 8. For windows of average size, Fig. 316, simple or rich, elegantly or plainly profiled, 6 1-2 in. wide, 1 3-8 in.

projection.

9 to 20. For wide windows, Fig. 317, more or less simple or rich, richly or plainly profiled, with or without sunken panels, breadth 7 in., projection 1 3-8 to 2 in. Figs. 317, 9 to 20.

In all these profiles, ease of execution, general effect, the projections of each fillet, cove and round, quarter-round and reverse ogee, are considered in the most careful way. The peculiarities found in these profiles are the following:

No. 1 has least projection. Nos. 2, 12, 20, have sunk panels. Nos. 4, 7, 8, 13, 15, 16, 17, have flat surfaces separated by rounds. Nos. 2 and 19 terminate with reserse ogees. No. 5 has an undercut quarter-round. Nos. 6, 9, 19, have reverse ogee with round. No. 9 has its entire profile projecting in front of the wall-face, an exceptionally permissible arrangement of heavy character. Nos. 15 and 17 have splayed bands. In all these profiles, the recalling of classic forms and the treatment of the architrave with imitated forms are suppressed as improper, the nature of the architrave being made prominent.

d. The so-called Ears.

Very ancient reminiscences of wood construction yet remain in the peculiar forms of the so-called ears of window architraves; if two window jambs, above which a lintel is placed, are connected below by a transverse piece, Fig. 318, we shall obtain the form of such an architrave in the simplest way; if the moulding is carried around the edges of the ears, the motive is enriched and the architrave of the window is harmoniously developed. The lintel, Fig. 319, must project at least 9-10 in. and must have a height equal to the width of the architrave; the window sill may also form an ear 9-10 in. high and should have about the same width, and as 1 3-8 in. is required for the wash, it must be 2 3-8 in. wider than the profile of the architrave. It is evident that only the outer members of the architrave mouldings can be broken around the ears, or at most only the principal band besides these; also that sunken panels, forming squares at the angles, are unsuited for application to the ears, like diamond panels, since ugly angles would be produced in the first case and ugly intersections in the last, Fig. 320.

If it be desired to break the entire profile of the architrave around the ears, their height must be equal to twice the width of the profile, Fig. 321; but the jamb must then be about 9-10 in. thicker, as a part of the ear must be worked on it, or the lintel must be stilted about half the height of the ears, Fig. 322. The latter arrangements are awkward. It is permissible to increase the height of the ear by the width of its outer moulding, so that the joint of the lintel cuts off a port-

ion of the ear, Fig. 323, when the jamb must be about 9-10 in thicker.

It is to be noted here, that a variation of the arrangement of the ears, found in stucco-work as well as in mitred wooden architraves, is only proper and justifiable in stone construction, when no attention need be paid to jointing and construction, as if the architecture were changed into pure sculpture, which is possible in the soft sone of Paris. In stucco or plaster work, one is entirely independent of the construction and may therefore change the ears at pleasure.

To employ inclined jambs, or to make them wider below than at top to obtain space for the ears, would be archaic and scarcely justifiable in normal cases; it should also be remembered that the height of the ears may frequently be fixed by wall members, band-like friezes that run along the wall, or by the arrangement of mouldings with less projection that the ears, Fig. 324. The Renaissance or Rococo idea of placing guttae beneath the ears to indicate that the window belongs to the Doric style is objectionable as being a pedantic fancy, like so many things devised by a mistaken classicism.

If a window jamb stands on a separate sill, which must project sufficiently from the wall to give space for the jamb, the following cases become possible: either the architrave moulding abuts against the sill, Fig. 326, against a low plinth, Fig. 327 a, against an inclined plane, Fig. 327 b, its foot is concealed by an ornament, Fig. 327 c, or the moulding is returned, Fig. 327 d, so that its external band forms a plinth.

The first and second arrangements have something undeveloped and therefore incomplete; the termination of the moulding against an inclined plane, an especial favorite during the Middle Ages, is the simplest and yet most primitive form, suitable for the forms of jambs produced by splaying; its importanc increases in case the moulding projects somuch as to require splaying for carrying off the water, as in entrances of large size and similar arrangements. Returning the moulding across the foot of the jamb is to be considered a Renaissance invention, and it may be either single or double, either merely arranged on the front, or also on the sides. Fig. 327 d, e. The most pleasing arrangement, though requiring most work in stone cutting, is that in which the foot of the jamb is concealed by an ornament, a mode of treatment much in favor in German and French Renaissance.

e. Window Caps.

The most obvious expedient for enriching the appearance of a window, at the same time partly protecting it from rain water and balancing the sill, is the use of caps above the windows.

A discharging arch is, in most cases, arranged above the archi trave of the window, above which a cap may find room; this is therefore separated from the architrave by a frieze-like inter space, Fig. 328; if the masonry is plastered, the discharging arch is concealed behind the plastering, if constructed of ordinary materials; if the arch be carefully built of stone or brick, it may remain visible and project beyond the surface of the plaster or the wall-face, Fig. 328; if the projection of the architrave is 1 3-8 in., that of the frieze may be about half as much. If the building be constructed of ashlar masonry, the discharging arch should consist of two or three ashlars, these being cut to voussoir shape, Fig. 329, or it should be concealed behind a slab of stone, which may be enclosed by a border, be decorated by ornaments in relief, or prepared from a better material.

The frieze must always project from the wall-face, if it is to act as such, and if it be also of plaster; but it must have only the same width as the window when ears are present, so as not to encroach on them. It is only proper to entirely omit this frieze when the cap and the lintel of the window are worked from a single block and are therefore strong enough to support the weight of the wall, or when a special discharging arch is placed above them. The cap will then rest directly on the lintel of the window, from which it should always be separated by a visible joint, Fig. 330.

The cap is a horizontal slab of stone built into the wall, which, in the simplest form, has a sloping wash at top and a drip at its lower edge, Fig. 331 a. Its projection requires to be supported by a moulding beneath to make it satisfactory to the eye, Fig. 331 b, and a better development needs a crown moulding above it, Fig. 331 c. According to the projection of the cap, with equal heights, the vertical surface may predominate over the upper and lower members as in Fig. 331 b, c, or conversely, may be reduced to a minimum by these, Fig. 332. The general character of the cap accommodates itself to this, and will be heavy with a thick slab and light with a thin one. The appearance of caps of equal height may be modified by a steeper or more nearly horizontal wash. The upper member, Fig 333, is a terminating or crowning one, the lower being a horizontal and supporting one, Fig. 334; evidently in richer arrangements these members may be decorated by leaf mouldings, beaded astragals, dentils and similar ornamental elements, according to circumstances. One may take 7 1-2 in. for the height of the cap in normal cases; if required to be lower, the wash may be more inclined.

The projection of the cap may be increased by

sliding out the cap and its drip further; this mode of increasing the projection is dangerous in that the cap appears heavy in proportion to the entire architrave of the window, though not sufficiently protecting this from rain; at the same time, it may appear to project too much at the ends. A moderate projection of the cap is therefore preferable, and its projection may be made less at its ends than its front, so that its under surface appears of unequal breadth, Fig. 335; the upper and lower members projecting equally all round.

It is incorrect to regard a cap as being a principal cornice on a reduced scale as usually done; the cornice and cap may often serve similar purposes, but are also essentially different in many cases. The projecting cornice, which crowns the whole may serve as the terminal member for many objects, buildings as well as furniture, so that supporting or crowning, light or heavy, lower and upper members appear desirable, without the need of a water spout, a leading feature of the cornice of the classic temple. By traditional custom the Greeks imitated the form of the water gutter where it could not be required, just as the architects of the Middle Ages from force of habit also employed the so-called gargoyle when useless. The famous door of the Erectheum, above which a regular cap occurs for the first time after the older Egyptian temples, and which is esteemed as of unique beauty by the orthodox Neo-Hellenists, exhibits a mixture of refined sculpture and a lack of architectural thought. A cap of similar character, whose crowning member is changed into a formal water gutter, may be appropriate in certain cases if the crowning member be made a gutter of thin metal above a widely projecting geison of thin boards. But the imitated gutter is meaningless, when a mere form, fulfilling no purpose, and if the Greeks had become accustomed to regard the cornice and water gutter as inseparable ideas, or had reached the false conclusion, that since a water gutter must be treated as a crowning member, conversely, a crowning member must be formed like a gutter, we need not imitate any nonsense of that kind.

Gothic likewise committed the fault of using the very appropriate wash with its drip, commonly employed as a cornice, as a natural form of cornice where no water was to be thrown off. The Greeks employed the geison as the principal part of the cornice, making this project as far as possible so that shelter from rain might be found beneath it. The Middle Ages feared torrents of rain but little and desired to get rid of the rain water as quickly as possible in rather a short-sighted way without caring enough for its final disposal or whether any provision would be made for this or not. The need of a

principal

principal cornice exists for a wardrobe, a stove or an altar, just as much as for a house or a tower; still, in the three first cases it will only act as a crowning member and not to carry off water. In the same way a cap may be required in the interior of a building, for furniture, niches in walls, and for altars, monuments, doors and windows, stoves, etc., to satisfy esthetic requirements without fulfilling any material purpose. There always remains an affinity between a cap and a cornice if their purposes are likewise allied, yet they are not identical, one being and remaining a cornice, the other a cap.

When a cap is required to have considerable projection its ends must be supported by consoles. The idea of a cap with consoles in the simplest form is that of a slab projecting strongly forwards and supported by a corbel at each end, Fig. 336; to make these appear effective the slab should project but little beyond them, only so much as necessary, while its ends may project more; the lower members of the cap are broken around the consoles, and the under side of the cap, to not appear too heavy, may be decorated by sunken panels, Fig. 337. The consoles may be placed above the lintel of the window or door, only occupying the height of the frieze; they will then have the same width as the architrave above which they are placed, Fig. 366, or are placed just outside the architrave, which extends between them, Fig. 338; a form of strong inclination is then preferable, corresponding to the slenderness of the window. No absolute rule can be given for their dimensions, yet it will serve as a basis to make their breadth 4 to 4 3-8 in. and their total height 17 to 21 in, exclusive of the lower member of the cap. These dimensions harmonize well with those given for architraves and those of the cap. It should also be notcied here that the lower members of the cap, broken around the consoles, should be worked on the cap itself, and therefoe in profiling them, aattention must be paid to the form of the cap and also to that of the consoles. When consoles are used, a decoration of the frieze above the lintel is then more justifiable because it may be treated with peculiar propriety as a decorative panel.

A further means of enriching window architecture consists in the arrangement of a window sill, on which stand the window jambs, and which partly serves a decorative purpose, and is partly desribale on esthetic grounds, and partly results from material requirements.

f. Window Sills.

The window sill is a kind of cornice, projecting sufficiently to receive the architrave, or at least 9 to 13 3-4 in. for fully

fully developed architrave mouldings. This projection is so great as to require some lower members, as the sill would appear too heavy without them, and these lower members must be supporting ones. If moulded jambs are used, the front surface of the sill would appear too heavy and solid if left plain; it may therefore be finished with sunken panels, but must then project more so as to afford the jambs a firm support, Fig. 339 This arrangement was already known in the classic period, examples being found in the Erectheum, and the Temple of Vesta at Tivoli.

In the rainy North the sill must usually have a drip to prevent the water from running down the wall, and this end is more perfectly attained when the sill has an upper crowning member, which not only throws the water further from the wall than a simple slab would do, but also gives the entire sill a nobler and richer appearance, Fig. 340. This upper member is generally returned at the ends of the sills; the result is that the water either runs down the wall at the angles of the sill, or that special precautions must be taken to prevent this evil; a further result is that the sill is wider than the window. The simplest means of leading the water away from the wall consists in forming a small spherical wash at the angles of the sill, Fig. 341, scarcely visible from below. The widening of the sill caused by the addition of an upper member makes its upper surface a very convenient support for persons looking out of the window, for flowering plants, etc. To better satisfy similar requirements, the Middle Ages and Renaissance sometimes corbelled out sills. The following modes of arranging sills are now most common.

1. The sill is isolated, not being connected with other architectural details to form a part of the enclosure of the window, simply projecting from the wall. The sill should have a moderate projection, only as much as absolutely necessary. Profiles similar to 1, 6, 7, 8 or 9, Fig. 343, may be suitable.

2. The sill projects from a continuous flat string course, along which are continued the upper, lower, or all the members of the sill, Fig. 342. If this continuous string course be flat and projects from the surface of the wall, the profile of the sill may spring directly from it (see 1 to 9, Fig. 342) or may project by the breadth of the lower horizontal fillet. A profile like 10 permits the sill to be made lower than the string course, while the lowest vertical fillet may coincide with the string course, Fig. 344. If the string course and sill are also moulded alike, the sill either does not project and coincides with the string course; or it requires to be supported by consoles, small pilasters of slight projection, or a

projection of the wall surface, in case it projects beyond the string-course. If the upper or lower members of the sill are omitted on the string-course, it should have a greater projection and a more solid character than in the second case; it in the first case appears as a strongly projecting cornice; in the second, as a lighter band with terminal or crowning members. Fig. 345. The projection of the sill may then be obtained in different ways, either by omitting the drip or the string course, by supporting the sill on small consoles, small pilasters, or by a projection of the wall.

3. The sill is supported by consoles. The same general rules then apply to the consoles as to the consoles of caps; they should have the same breadth as the architraves beneath which they should be exactly placed; they enclose a space between them, if as often happens, they rest on a base or are connected by a small band beneath their lower ends, Fig. 346, and this frieze-like interspace likewise affords opportunity for decoration by sunken panels of all kinds. The upper members of the consoles, when these are also lower members of the sill require consideration on both points. The under side of the sill, like that of the cap, may not only be decorated by sunken panels, coffers, etc., but must be so if the sill projects considerably, to remove the character of heaviness from the view of the under side.

4. The sills rest on a slight projection beneath the window. It will often be deemed advisable to form a projection beneath the window, which not only gives it a more slender character and is therefore necessary, if the height of the window is small in proportion to its breadth, but is also desirable for widely projecting sills, which it is not desirable or possible to support by consoles. These projections may be left smooth or be decorated by sunken panels of all kinds, Fig. 348, by medallions, heads, wreaths, etc., and may be limited at each side by short pilasters that enclose a sunken panel. Fig. 346.

5. The sill is formed as a low base, which may be connected with the base of the building in basement story, Fig. 343. This may occur for different reasons. In cases usually found in houses, it may be desirable to restrict the normal external height of the window projection to about 31 1-2 in., part being a wall, the remainder an iron lattice; this will be permissible if the windows of the belle etage be so arranged that their sill forms a seat on the interior, above which is placed a balustrade of iron lattice-work or a fixed window, to serve as a back, or a second balustrade intended to support the arms. This will also be the case if higher proportions are to be given to the low windows of a mezzanine or upper story; or if

for special reasons it be desirable to not place the string course, as in normal cases, at the same height as the inner beams, but higher, to give a stronger construction to the windows and their discharging arches in the lower story. The string-course is then usually placed at the same height as the sill, but may be placed lower if required, and the sill be then formed like a low base, Fig. 343. It may be advisable to mention a fourth case, that of making the entire height 31 1-2 in. of masonry and inserting a low projection between the sill and architrave, which is returned across below this panel, Fig 347; finally, a similar arrangement may be necessary or proper for the reason that the base of the window in the basement story may be combined with the base of the building, and perhaps form a group with the cellar window also, Figs. 348, 349, 350.

The drawings of forms of windows given in Figs. 348 to 350 are from the Dresden School.

g. Abnormal Forms of Windows.

The Italian High Renaissance invented a form of window in a perhaps isolated case, which harmonizes with the rude character of rustic masonry without differing from the general form, and consists in a simple treatment of the narrow architrave by means of flat bands and splayed surfaces, with the necessary rebate for the window shutters. The considerable thickness of the walls of a basement story afforded wide jambs and soffits for the windows, hence narrow architraves and simple and sever profiles, of which a few varieties are given in Fig. 351, are fully justified. For the same reasons, rusticated windows of a basement story or of shops are treated with simple architraves based on the motive of a splayed surface, Fig. 352. Since the windows of shops generally require a special arrangement for reception of iron shutters, the weight of their architraves is increased by the wooden frame, and the space between the two for receiving the shutters of plate iron. The simplest mode of forming the sections of rusticated windows is to omit any special architrave; the rustication then either ends in front of the jamb of the window, or is returned around it, stopping against a reveal, which also determines its greatest projection, Fig. 353. A further simple form of window is a favorite in the Italian Renaissance, especially for modest buildings or for subordinate windows. It consists in leaving the outer surface of the jamb flat, its inner edge only being bordered by a simple moulding, which may both project beyond the flat surface and recede behind it, Fig. 354. From these two motives are developed two very pleasing others by corbelling out the sill, and by carrying the flat architrave around it or not. The corbelled sill may have forms very varied in plan,

.g. 355, and its profile may be formed independently of the profile of the architrave, Fig. 355.

Another motive, derived from these and similar arrangements, consists in decorating the outline forms of the outer band; especially with forms of console-like volutes in connection with foliage and palm-leaves, employed during the High Renaissance for the most diverse purposes; to lend a decorative character to the smaller windows of mezzanine stories, or those intended to light vaults of rooms, in contrast with the more severe forms of the windows of the principal stories, Fig 356, 357. Roman buildings especially used this expedient.

From this was developed the inexhaustible motive of the enclosure of inserted sculptures by architraves, built into the walls as if found on the site of the building by the excavators, and which were to be harmonized with the architecture, Fig. 358. The late Renaissance obtained the most varied effect by combining all these decorative motives with caps, sills, consoles, and other window-motives. This is not the place to go into all these details, principally borrowed from palatial architecture, and reference must therefore be made to publications on Italian, French, and German Renaissance, which afford a multitude of ideas for use in rare cases.

Mezzanine windows usually have greater width than height, are therefore sometimes divided by a central mullion, are square, or their height more rarely exceeds their width. In exceptional cases, according to the architecture in which they are employed, they may take any suitable form other than rectangular, be treated as wheel-windows, or formed in any other way, Fig. 359. The same is true of all smaller openings found in all kinds of buildings.

h. Abnormal Forms of Caps.

Different requirements may exist, which in houses of several stories lead to dissatisfaction with simple forms of window caps and to a search for richer forms. The principal cause of this is always the desire to emphasize the different stories of a building. Natural requirements and associated ideas led to the treatment of the basement as the heavy, bold and simple story; of the belle etage as the most prominent of all, severe and yet noble, and of the uppermost as the lightest and most graceful, requiring and capable of the most decoration; a ground-law of architectural treatment also consists, not in seeking variety and richness in change of motives alone, but in the enhancement of motives. From simple window architraves we have obtained the following series of motives.

1. Architrave without ears; 2, architrave with ears; 3, architrave with caps; 4, architrave with cap and sill; 5, archi-

trave with caps above consoles; 6, architrave with cap, and sill supported by corbels; 7, architrave with cap and a special projection of the wall as a base below the window; an enrichment of the motive leads to 8, where an angular pediment cap is introduced; and further to 9, with circular pediment cap; which becomes the decorative circular cap 10, by interrupting the cap by an ornamental group. In exceptional cases, a cap receives an attic for reception of an inscribed tablet, 11, or 12, a purely ornamental centre-piece. Fig. 360 a, b.

Take, for example, a four-story detached house, Fig. 361, which is to have four different facades, a being the unbroken principal facade next the street, b the facade next the garden with a projection and the principal entrance, c and d being the garden facades with projections; each story contains a small flat, consisting of kitchen and appurtenances, water closet, dining room, reception room, living room, bed room, three windows in each facade being sufficient. The house possesses ungraceful proportions; the basement should therefore first be separated from the other stories by a string course, and the upper story treated like a frieze or enclosed by a band, to balance the basement story. We now have to make the windows of the belle etage more prominent than those of any other story, so as to characterize this as the best story. We therefore furnish its windows with caps with consoles, connecting them by a light string-course to still more moderate the proportions of the house. One angle projection of the house contains the living room and is subordinated on that account; the other projection contains the dining room and is so placed as to enlarge this and increase the varied effect of the whole The living room is characterized by a window with angular pediment. If we assume the dining room to have a balcony, the door to this balcony also serves as a window, would differ from the other window , and would therefore require its special distinction. To treat the windows of the kitchen, W.C. and dining room more plainly than the remaining ones of the same flat will hardly be proper if a pleasing appearance of the house on the garden side is required, for the unity would suffer from too great variety, and this inferior treatment would indicate those rooms, which should be ignored as much as possible.

The treatment would be lowered somewhat in the second story; the window of the living room in the projection would receive a cap without pediment but with small consoles. The other windows of the story should have caps without consoles and without separate sills. Finally, the windows of the third story would merely have architraves and would produce a sufficient

effect by their connection with the frieze; yet the window of the living room may be distinguished by a decorative cap, Fig. 360. The windows of the basement willfulfil their purpose if they are of simple form, as they act in conjunction with the base of the house, and a more severe and simpler treatment than that of the windows of the belle etage will be proper.

In a house with four facades, but two of these will be seen at the same time; hence unity and variety are to be considered in the two facades visible at onee. The principal facade appeasr perfectly symmetrical here, because but a single kind of window is found in each story.

The side and rear facades taken together, form a group of varied, yet united effect. There still remains the treatment of the doorway, which must usually have a transom light for lighting the hall. If the windows of the staircase hall are arranged in the usual manner, not at the same height as the windows of the stories, but with reference to the landings, this not only gives rise to many peculiar combinations with the string courses, but may perhaps exercise a reacting influence on the forms of the other facades. Since a harmony of the facades may only be obtained when all the motives occurring on them find their fullest development, the arrangement of the staircase windows assumed here conflicts with those of the other facades, and requires to be softened. The staircase windows serve purposes other than those of the living rooms and should therefore be developed in a different way. The lowest window serves as a transom for lighting the hall and may receive an angular pediment cap; or in its place may be used a tablet inscribed with the name of the owner, date of erection, etc. The window above this has a decorated circular pediment, whose character is always less severe than that of an angular pediment cap. The uppermost window may have a purely decorative cap.

We have here given an indication how artistic expedients should be employed in a special case. The general ground-laws of contrast of effect and of internal and external truth determine our choice of the different motives of form, starting from certain normals, not throwing together motives at our fancy. The law of enhancement of motives, with the other law that a series of similar elements require the middle and ends to be made prominent because being special points, or that their recurrence in a periodic series must be accented, requires the strongest motives to characterize the points to be made most prominent, and the weaker to be subordinated, and a strict attention to simplifying the motives of the different stories.

In a villa consisting merely of a basement and first story, it would be in accordance with the means at our disposal and also with the character of the building, to select for the windows of the belle etage or lower story a stronger or richer motive of form, than for the upper story; a window with cap and sill, both on consoles, would usually be sufficient for richer designs; but the stronger motive of the angular pediment, or the weaker one of a decorated cap, would be restricted to those windows of the same story, which are to be specially characterized; thus the strongest motive must not be selected for the general one, leaving no means remaining for distinguishing special cases, and requiring one to descend to a lesser motive. In the same way, the forms of the other and subordinate story should be reduced a degree, that the belle etage may have its due effect. If the basement be also the belle etage, a combination of the architecture of the windows with the base and the the cellar windows in a grouped motive , or the combined effect of these elements as a whole, even if not connected, will appear so bold and so rich, that the sills do not require the additional effect of corbels.

The windows of the upper story, which only contains the bedrooms, breakfast room, nursery, dressing rooms and guest chamber, while the belle etage contains the rooms for social purposes, the master's room, living room, etc., should therefore be treated in a subordinate way, be simpler, and therefore lighter and less severe. Conversely, if the belle etage be the upper story, and the ground floor be allotted to inferior purposes, the basement must be simply and boldly treated and be heavier, while the belle etage requires richer and still str strong and elegant forms.

The Italian Renaissance may be reproached with having retained Doric, Ionic and Corinthian orders as a fixed series of the characters of the stories, calling the circular pediment Ionic, and the angular one Corinthian, forgetting that in comparing round and angular pediments of equal height, the round pediment always possesses the character of heaviness with less strength than the angular one; this caused a contradiction in the architecture of many palaces and houses, if Doric columns were employed in the basement and Ionic in the first story, with alternating circular and angular pediments, as in the Pandolphini Palace, Florence. Alternation of round and angular pediment caps in the same way has its advantages, if the story contains more than three windows; a certain contradiction even then remains, as on the facade of the Bartolini Palace, Florence; the stronger motives are too much concentrated. If the caps alternate in case of four windows, as in the Pandolphini

Palace, Florence, and the Farnese Palace, Rome, a doubly un graceful result is produced as the ends are different without any reason therefor, and the centre is not accented. An alternation would first become suitable in case of five windows, especially if angular pediment caps were used at the middle and ends, with cricular pediment caps over the intermediate windows. Palladio used this expedient in the Chieragati Palace at Vicenza with good results. In case of a longer series of windows, round and angular pediments should preferably only be employed as a means of emphasizing the centre and ends. The adjoined schemes, Fig. 362, give examples of ways in which a change of motives is admissible in different cases without injury to the untiy or variety.

i. Forms of Pediment Caps.

As for the forms of angular and circular pediment caps, their heights may be made about 1-4 to 2-9 their spans. The mouldings of angular and curved pediments are similar to those of horizontal caps; the two following cases may occur; the upper or crowning member is either merely carried around the pediment cap and omitted on the horizontal return, which terminates at top merely with the member connecting the facia and the crown mould; or the entire moulding is carried along the horizontal cornice, on which the moulded gable rests, and stops against a slightly inclined plane. In the first case, the intermediate fillet encloses the tympanum; in the last, this is done by the upper fillet b, Fig. 363. The upper member a, if fully developed in front as well as sidewise, requires to be slightly broken at the angle of the cap, which in reality is less disturbing than if the profile be distorted at the angle.

The vacant space enclosed by the mouldings of a circular or angular pediment is properly decorated by an ornament, a shi shield of arms, head, wreath, by decorative sculptures, etc, Fig. 364, so as not to produce the impression of emptiness and heaviness; the back-ground of this tympanum may project beyond the face of the wall if the pediment is supported by consoles.

Classic and Renaissance styles gave the same profiles to angular and circular pediments and to the horizontal caps on which they rest. Strictly speaking, this is unnecessary; the pediment is always something different from the horizontal cap and it has too heavy an effect in many cases, if both have the same profile; in the horizontal cap, the geison is the principal part, but is of secondary importance in the pediment, and the crown mould of the curved or angular pediments will take the first place, as being the crowning member of the entire window, the geison playing a subordinate part; it will therefore not be improper to make the geison of the angular or cur-

ved pediment narrower than that of the horizontal cap to allow the crown moulding of the former to predominate, the latter ending with merely a terminal member, and to make the supporting lower member of a pediment lighter than that of the horizontal cap, Fig. 365.

Broken circular pediments are produced by accenting the middle of the arch by a grouped ornament of any kind, (foliage, suspended garlands, wreaths, shields of arms, vases, palm-leaves heads, etc.), placed between the volute-like ends of the broken curve, Fig. 366. The upper fillet of the crowning member is curved around an eye, formed like a rosette, against which, and the ornament, the other members stop. These broken circular pediment caps, as well as the purely decorative caps, nothing else than ornamental crownings above horizontal caps, permit a free treatment, which may be varied in accordance with the special case in which they are used.

If it be justifiable to break the less severe circular pediment caps and give them a decorative character, to break angular pediments at the apex, a favorite idea in late Roman and late Renaissance, so that a bust or other sculpture may project above the apex, is an objectionable expedient of degenerat art, which passes beyond its natural limits. A given motive may not be modified or enhanced at pleasure, but only within certain limits. Many things indeed exist, which according to general laws, are more or less pleasingly formed, but the propriety of their existence is not based on their pleasing apperance, but on the purpose which they may serve. This pleasing effect only takes the leading place in free ornament.

j. Cap with Consoles.

If the caps be supported by consoles, these flank the jambs on either side, and the ears are then best omitted. The consoles project directly from the wall-face, or from a pilaster of equal breadth, which may be flat, or be bordered by an architrave moulding, Fig. 367. The width of this pilaster will be fixed by the fact that the console, to appear capable of supporting the cap, must have greater height than breadth; the higher it is the narrower it may be, but the lower it is the broader it should be. The width of the pilaster must be determined accordingly, but in normal cases will be narrower than the architrave of the window. If the projection be broad in proportionally low consoles, the architrave of the window must be made proportionally narrower, as in Fig. 367, since the entire finish of the window would otherwise appear too wide in proportion to the clead width of the window.

This pilaster always requires some projection from the wall-face and panelled ashlars may not therefore abut against it,

but must be separated from it by a margin. If the window has a base beneath the sill the pilasters require separate bases. The effect of the pilasters will vary in accordance with their sections, and whether they are behind the band of the architrave or in the same plane with it. If one desires to lessen the projection of the caps of the windows at each end, the consoles may be placed directly above the jambs and the lintel of the window, enclosing the frieze between them, Fig. 366. They then take the same breadth as the jambs, and their projection is determined by their section.

The consoles themselves are either low and broad, as in Fig. 366, 367, 368, 369, or are high and narrow, as in Figs. 364, 370, 371. Consoles resting on a base and supporting a sill may be arranged as in Fig. 372. In consoles under sills, a difference is to be made whether they stand on the architrave, or under a pilaster, Figs. 370, 371. A further difference consist in their being upright as in Figs. 366, 367, or suspended as in Figs. 368, 369, i. e., whether the eye about which the volute is coiled is above or below. For pediment caps, narrow and high consoles as in Fig. 364, are preferable to broad and low ones, which are more suitable for lighter caps and sills.

Balcony consoles, two examples of which are given, in Figs. 373, 374, generally require strong projection of bold character. It is frequently necessary to arrange several consoles one above another like corbels, each supporting the one next above, especially in designing bay-windows, which require strong supports, not for structural but esthetic reasons. Such corbelled arrangements may be most simply profiled by being allowed to project slightly sidewise and strongly in front Fig. 375; decorative forms may take the place of mouldings.

For ordinary house construction, using cut stone, a horizontal window lintel is most suitable for practical and esthetic reasons. Even in brick construction, for which the straight arch may be used, it is better not to employ arched windows in the construction of houses, at least not for living rooms, but for staircase halls; for practical reasons, since arched windows admit less light than rectangular ones of equal height, and for esthetic reasons, in order to give the house a character different from that of palaces and public buildings. One should also be satisfied in house construction with the modest artistic expedients already described, and reserve richer and bolder forms for public buildings and palaces. (Rectangular windows are usually rare in brick buildings in the U.S.)

2. Windows of Public Buildings and Palaces.

For the architecture of such windows, the determining consideration of first importance is that the windows are generally

larger and light rooms of greater depth than in houses, and t the external walls are thicker. The windows therefore requir greater width and height, their jambs are wider, and their ce tres are farther apart. From their requirements, these build ings are on a largerscale, more solid and massive than houses and thereforerequire bolder artistic expedients. The greater width of the windows is first, since this has a decided effec If the windows are rectangular, careful attention must be paid to relieving the lintel of load, and it must have a greater height than in houses, to not break at its centre. In simple ashlar masonry, the lintel will be a single block, and to relieve it, the stones above it must be supported by corbelling and radial jointing, Fig. 376. If jambs are used, it may happen that a frieze is formed below or above the architrave mou dingas at a or b, Fig. 376. A corresponding case is when the lintel of the window forms a complete entablature supported b pilasters, which also project from the wall surface, Fig. 377. This entablature has its crowning cornice with or without pedi ment; a separate architrave, composed of two jambs and a lintel, may enclose the opening. If the pilasters be replaced by columns, we obtain the canopied window, such a favorite in th High Renaissance, with all its consequences, such as the pedestal, perforated window parapet, etc. But this window architecture requires either a bold recession of the stories to per mit the columns and their pedestals to stand free in front of the face of the wall, or the pedestals of the columns must again be supported by columns, consoles or caryatids. This win dow motive may also be developed into complete bay-windows, en riched by doubling the columns, by the aid of pilasters, or may be changed into the frequently employed loggia motive by introduction of arches over pilasters or columns.

The arched window is developed most simply from ashlar construction. Italian palace architecture developed the arched window in the most complete manner; arches are absolutely req quired by the great width of the window. Its form results from the structural principle, either a special stone architrave being formed, projecting from the wall-face, and which may be crowned by an entablature and pediment or a circular cap, or the archivolt moulding is wrought on the ashlars themselves. If the window is so large that the glass requires intermediate divisions, these are provided by the use of small columns or pilasters, which limit the openings in the window, the motive of the windows of the early Florentine palaces; the small columns are covered by a horizontal lintel or spanned by arches, the tympanum above them being perforated, so that a kind of window tracery is produced, with the same meaning as

that of the mediaeval. If the window consists of three divisions, it naturally results, if no horizontal lineel is used, that the middle part is made as high as possible, and the spandrels are filled by circles, Fig. 378 a. In case of a horizontal lintel, a large circle in the centre with a smaller at each side is an appropriate arrangement, Fig. 378 b.

A horizontal lintel, Fig. 378 b, does not generally look well if the tympanum of the window is filled by circles or by other closed figures, as the tangency of a complete circle and a straight line is not so good esthetically, as if it were tangent to one or more curved lines. One of the best proportions for windows of three divisions is obtained by dividing the diameter into three equal parts, describing small circles on 1-3 the diameter next each springing, then drawing a large circle between them and the semicircle, letting the semicircles of each division of the window be tangent to these three circles, Fig. 378 c. The sprining point is thereby lowered and the upper tracery gains in importance.

Another motive for dividing windows in two or three parts, only applicable to rectangular windows, is to palce horizontal lintels above the window jambs, forming transom lights above them by means of short pilasters also connected by horizontal linaels, Fig. 379 a. This arrangement is particularly justifiable when the transoms are fixed, only the lower portion of the window being opened. The transom bar must then be moulded to form a wash. The central vertical mullion may then be treated as a supporting pilaster. In windows of this kind containing three divisions, the central transom bar may be omitted, making the central window higher than the side windows. The different mullions may likewise support circles and semicircles, Fig. 379 b.

3. The Church Window.

The church window falls outside the limits of ordinary construction, both from its considerable dimensions, and especially from its height, as well as by its purpose of lighting the House of God, and one must avoid everything of a secular character in its appearance, as well as all decorative expedients, tending to recall the construction of houses and palaces. The considerable thickness of the walls afford broad jambs, usually splayed with or without mouldings. If the windows are not simple openings between piers or columns supporting entablatures, but are spanned by arches, all the forms of arches permissible in secular architecture are to be excluded with the exception of the indispensable semicircular and pointed arch, which, if slightly pointed or depressed-pointed, is always appropriate in church architecture, unless forms of classic tem-

temple are willfully introduced, will always return to the forms introduced by the Middle Ages more than secular architects, assuming that the structural principle is to govern. On esthetic grounds, the pointed arch retains its superiority over the circular arch if properly used. Thus in a group of three church entrances or windows, a pointed arch between two semicircular ones gives a more varied appearance than three semicircular arches. In using the pointed arch, we are not obliged to accept all the consequences resulting therefrom in Gothic. If we do desire to build exactly in Gothic, but to rationally deduce architectural forms from structural and esthetical requirements, in many questions of church architecture we shall still touch upon the Gothic style, but must carefully avoid everything specific to that style, and which may as well or even better be replaced by other forms.

4. The Wheel Window.

We can never exclude the wheel window from church architecture. It always remains the form of window most pleasing and most suitable for certain purposes. If the wheel window be not divided byaan iron frame-work for the glazing, but by stone work, one should always recur to motives common in the Middle Ages, and either arrange around a centre radial mullions, whose outer ends are connected by arches in any way, or a system of perforated slabs, in which the detail forms specifically belonging to Gothic and Romanesque should be very carefully avoided. A circle is a general form and always required in architecture, but the foils and cusps of Gothic tracery are specific and no longer necessary in church architecture. A scrol work of plant stems may be used as a motive for the tracery of church windows with the joints horizontal, or arranged in accordance with principles of arched construction. In this way, tracery may be invented, whose form entirely corresponds to the principle of the Renaissance style, while its construction and moulding are in accordance with the mediaeval principle. Fig. 380.

5. Window Tracery.

Vertical divisions of windows may form a system of mullions like those of mediaeval tracery, or a system of perforated horizontal slabs of stone placed one above another. In this case also, the form-principle of the Renaissance admits of the most varied forms, scroll-work, tapestry patterns, the use of figure, plane, and ornamental decorations of all kinds. The mouldings are similar in principle to those of mediaeval styles, even admitting a freer treatment. A freer form of patterns of window tracery is suitable for the Christian church, a more strictly geometrical one for the synagogue, without the neces-

sity of borrowing from the Moorish style. After the classic method, it is possible to divide windows by placing pilasters above each other, supporting horizontal intermediate cornices and connected by arches, Fig. 381. These cornices require a wash on top. The lower part of the church window best stands on a splay, Fig. 382, which carries off the water and ends with a drip moulding to keep the water off the wall.

6. Transom Windows and Skylights.

Small windows frequently serve to light upper galleries of halls as well as the ceiling. If they are not windows of ordinary and normal form, they may take different forms, as permitted by the external architecture, circular or oblong, with angles cut off, semicircular, etc. They are always subordinate and are preferably treated in accordance with the arrangement of the facade. They are sometimes placed in the frieze under the roof-cornice or its entablature.

7. and 8. Doors and Gateways.

For doors and gateways of rooms, public buildings, palaces and churches, the same is applicable, as for openings in walls in general, and a portion of that stated in regard to windows. In the simplest form, the door is merely enclosed by an architrave, either with jambs and a lintel projecting from the wall face, or by mouldings receding behind the wall-face and wrought on the ashlars. The architrave should be changed below into a kind of plinth in some way, either simply dying against this or returned around it.

The section of the architrave should have 1-7 to 1-2 the clear width of the doorway. In the early Florentine palaces with their massive bossed ashlars, the breadth of the architrave is about 1-2 that of the door. The doorway will appear weakly or strongly protected, according to the width of the architrave, and a strong protection will appear the more desirable, the greater the opening of the doorway, and may become the principal motive of the artistic treatment of a city or fortress gate, a tunnel or gateway bridge.

Simple rectangular doors with horizontal lintels yield the following motives with the aid of the columnar orders.

1. The architrave has an added frieze and cap; the progressive additions for enriching this motive are; consoles under the cap, pilasters on which rest the consoles, a pediment and attic story or transom window above the cap, additions which admit of the most manifold variations of form, according to special circumstances.

2. The architrave of the door is flanked by pilasters or columns supporting an entablature. The pilasters or columns may be with or without pedestals, may be arranged in pairs,

the entablature may be crowned by a pediment, or may form a balcony.

Doors and windows, covered by arches, admit of a series of motives, from the simplest to the richest, with enrichments by the expedients already mentioned, especially by making the springing blocks and keystones prominent. If panelled ashlars be added, as in many palaces, or three gateways are connected in a group, the richest forms are produced, like those invented by the Italian Renaissance in palaces, gates of fortifications and cities, and also those erected in modern times. The last motive of the triumphal arch may be varied in different ways, according to whether the openings are of equal width or the middle one is widest, or whether coupled pilasters or columns, with or without pedestals, are used, and from this by placing a second one over the first, was derived the motive of a two-story triumphal arch used in many Renaissance churches. The motive of the triumphal arch is also the one best suited for magnificent city gates and will so remain, since the central opening of wider span for carriages, and the narrower side openings for persons on foot, can scarcely be more properly combined in a group than in this way. By the addition of an attic, a crowning group of figures, and especially of sculptured decorations, or by flanking it with two successive towers, the motive of the triumphal arch forms a decorative architectural work of the first rank, which may as well be employed asa a motive for a city gate or the portal of a bridge as for the facade of a church.

In houses, palaces or public buildings, where the plan permits, a small porch should be arranged before the entrance door Fig. 383 a, b, or a projecting porch is constructed, which supports a balcony or terrace. Both arrangements admit of the most varied forms, according to their connection with the other architecture. Such porches are much used at principal entrances of churches and are often indispensable for protection from wind and weather. They are then placed between two towers, form the lower story of a tower, or project from the facade. On account of the thickness of the walls, the portals of churches always have very wide jambs, and should always more or less closely approximate Romanesque church portals in external form, yet avoiding all that could recall these. This results from the given conditions that lead to like results in similar conditions.

9. Portals of Tunnels, Gateway Bridges, Culverts, etc.

All openings in walls, comprised under this heading, serve purely material needs and usually require but a small amount of decoration, entirely dependent on the purpose of the structure

ture. In a city, tunnels, bridges and fortifications require greater expenditure for architectural purposes than in a wild mountain solitude; but even the least important of such necessary buildings must fulfil their purpose in the most complete way, and a form must be given them better than the requirements of absolute necessity.

Tunnels for railways, canals or other highways, will always be located where is to be found stone suitable for structural purposes. They are openings requiring enclosure, and being almost always arched, this arch of itself forms the enclosure. Rusticated ashlars, bold archivolt mouldings, a prominence of the springing and keystones of the arch, will form the most natural expedients for their decoration. Facades are sometimes built in front of tunnels, which may be crowned by a cornice with battlements or a parapet flanked by angle towers and decorated by shields of arms and inscribed tablets. All superfluous decoration is usually to be avoided, if not in a city or exposed to the view of persons on foot. The time for observing the architecture of a tunnel while travelling by rail is usually so brief, and the change of impressions so rapid, that the portal of the tunnel is only momentarily seen and its form is quickly forgotten. It is somewhat different if a street extends along the railway, so that persons on foot have time and opportunity for examining the structure.

It is generally advisable in engineering works and fortifications, for economy, to make extensive use of rock-faced ashlar masonry. Such structures derive thence a character of earnestness and strength. All petty forms are entirely forbidden in this case as they do not harmonize with the character of these usually massive structures. Battlements are always suitable for crowning walls, because a simple and effective motive. For projections of cornices, massive corbels, corbellings like those under bay-windows, and similar simple expedients aregood

Embrasures, openings for ventilation, and similar subordinate openings in walls, openings for discharge of water, etc., are best left simple, as required by their purpose, without further development. It is natural for openings in walls to be treated in accordance with their importance and location. The more subordinate, the less stress should be laid on making their forms more elaborate than required by the material need, avoiding all that might appear pretentious. Solidity of the masonry and careful execution must be the principal means for determining the appearance of the building. The Barocco style indeed went so far as to decorate the embrasures of fortifications, one of many errors that we must avoid.

Chapter 17. Floors and Pavements.

1. Stone Pavements.

Stone pavements for streets, squares, courtyards, etc., are either composed of specially prepared paving stones, of stones from rivers, or of quarried stone. Such pavements are now seldom used, that require decorative treatment, but when these are desired, stones of two colors are used to form simple enclosed panels, and they must evidently be of equal hardness. Such pavements were formerly composed of stones of different shapes, square, oblong, etc., and an example is found on the Cathedral hill at Trieste, Fig. 384, and another at Rome.

Pleasing pavements have been constructed in various places with river stones and quarried stones, which must have approximately equal size. Square panels are usually formed with the larger stones, their diagonals being also indicated, or oblong panels are filled with closely set stones. If the river stone are long and elliptical, they are usually arranged in "barley-ear" bond. Separate figures may be formed of small stones in mosaic-like patterns. Fine examples of such pavements are to be found in Freiburg-in-Baden, in the greatest variety of patterns, were carefully constructed with river stones, and with separate mosaic-like figures.

2. Floors of Stone Slabs.

The simplest kind, also used for pavements of entire cities, is that composed of stone blocks, like antique street pavements. The polygonal pavements of Florence are imposing, with their very large and carefully laid stone slabs and blocks. Square slabs are much used for covering floors of churches, vestibules, corridors and passages, courtyards, etc. A favorite method is to use differently colored kinds of marbles, producing mosaic-like patterns. A specimen of ancient stone intarsia from St. Gereon in Cologne is composed of slabs of Rhenish roofing slate, into which are cemented figures of tufa; a second one at the same place consists of slabs of white sandstone, into which are regularly inlaid figures of red and green porphyry. Intarsia and mosaic floors may represent geometrical or ornamental tapestry patterns, or even figure compositions as in many Pompeian houses and in the Cathedral at Siena.

3. Floors of Bricks and Tiles.

Ordinary brick paving is always laid in regular bond, and the decorative bonds are to be recommended for bricks set edgewise, producing patterns of all kinds. If it be desirable to employ colored bricks, they must not be enamelled, but must be self-colored to retain their appearance after use and to prevent slipping. It is permissible and also proper to make brick pavements of moulded blocks of forms suited to a mosaic system Especially those with connected figures

Especially those with connected figure elements, to accent the solidity. Artificial stone may also be used instead of bricks if composed of very hard materials. These are used in the form of small cubes or triangular prisms which compose the most varied geometrical patterns. Either flat pressed, raised or sunken tiles are employed for tile floors. The first may have the pattern burnt on in different colors as in Mettlach tiles. The patterns always form a tapestry-like network in either flat or pressed tiles, whose form depends on the stamp used for impressing them. The same laws are applicable to tiles set in walls, except that glazed or vitrified tiles should be used, which are less suitable for pavements on account of danger of slipping.

4. Floors of Artificial Stone.

Concrete floors are composed of beton, cement, or plaster of paris, laid on an under layer of bricks. A pattern may be produced by mixing different colors with the mortar. A very suitable treatment is that employed in the Library of St. Lorenzo at Florence, where the forms of the floor are directly based on those of the ceiling.

5. Wooden Floors.

The only wooden floors mentioned here will be those of parquetry. They are either composed of matched pieces of wood, or are veneered. They are always wood mosaics or intarsias, which determines their form and prescribes their limitations. The mosaic system is especially suitable for forms of veneered floors, the separate elements being cut from blocks of corresponding cross sections. (Much used in the U.S. Either, 1. composed of solid blocks tongued and grooved together; 2, of thin blocks glued on canvas backing; 3, composed of end-wood blocks connected by lead tongues and laid in squares).

Chapter 18. Treatment of Buildings in Stories.

1. Height and Character of the Stories.

The heights of the stories are determined by the heights of the rooms, and these depend on their areas. An old rule gives as a basis, that the height of a room should equal 2-3 to 3-4 its width; or 1-3 sum of length and breadth; or the half diagonal of its plan.

(Durand gives the following in his Leçons d'Architecture

1. Ceiling horizontal.

Height equal depth if length be greater than depth.

Height less than depth if this equals the length.

2. For arched or vaulted ceilings.

Height equal to 1 1-2 depth, if length exceeds depth.

Height equal depth for square, polygonal or circular rooms.

These proportions must be reduced for very large rooms.

Fergusson gives the following rule in his Historyof Architecture. Height equal to the square root of length plus hald the depth.

Proportions chiefly depend on purpose of the room, style of architecture, importance of the structure, etc. The present tendency in the U.S. is to make heights of rooms less than formerly, because more effectively and economically warmed and ventilated, and a larger rental can be obtained for a given area of ground and expendituse for building, etc. Rooms should never be less than 8 ft. high in the clear, best about 10 ft. for ordinary cottages, 12 or more for better houses).

The external character of the stories, their purpose, and their height, are always intimately connected. The cellar story of houses or public buildings will always be subordinate, even if containing living rooms. Its height does not exceed that of the base of the building, and it requires a plain and massive treatment.

The basement may have a different purpose and is occupied by shops in city houses, which require the widest show windows possible, or by modest dwellings. It is very commonly the pr principal story of villas, containing the rooms for social purposes, the upper story being occupied by bed-rooms, nursery, rooms for geusts, etc. The basement is then the most richly decorated story.

The first story is generally the principal story or belle etage, both in houses for renting as well as in palaces and public buildings, and its external appearance must therefore express this in its architecture. It will therefore be more richly and elegantly treated while the basement is simple and massive. If a mezzanine story be used, it must be treated with discretion, and be similar to the first story.

A second or third story is always subordinate. In large houses for renting, these stories perhaps contain two or three separate flats, while the principal story contains only a single dwelling of high character. The second and third stories are accordingly to be more simply treated.

An uppermost story, which contrasts with the basement in buildings of three or more stories, should in very many cases be formed like a broad band, connected with the main cornice, and terminating the building at top in a characteristic way. Since it usually appears too low and light in comparison with the heavy masses of the lower story, it should also be more lightly and decoratively treated, and it may be frequently connected with dormer windows and crowning gables. To connect together the windows of the upper story, wall-panels, niches

with figures, arcades, etc., are arranged.

An attic may be placed above the principal cornice behind which is concealed a story in the roof, it may be characterized by dormer windows, or a so-called mansard roof may be built.

In rare cases, the upper story of a house of several stories is the principal story, as in many Italian cities, where the belle etage is placed at top on account of the fresh air and fine view, while the lower stories are devoted to subordinate purposes, offices or less expensive dwellings.

2. Water Tables, String Courses, Cornices.

a. Water Tables.

Most buildings are terminated at bottom by a base, which forms the transition from the masonry of the foundation to that of the basement, and projects in front of the wall-face by about the difference in thickness of the two walls. If cellar windows are employed, they can be arranged in the base, which extends around the building like a broad band.

The base most appropriately begins with a wide member and is crowned by a cap, above which begins the lower part of the lower story, Fig. 385 a. The top of this cap is at the same height as the tops of the beams of the internal floor. The lower member is usually separated from the die of the base by a base member, Fig. 385 b, and is inclined if necessary; the cap also has a crowning upper member and a supporting lower one, Fig. 385 c; its upper surface is inclined, and its edge may also be inclined forward, Fig. 385 d. Above the wash of the cap is placed the base-member proper of the wall, which may be broken around any existing projections beneath windows. These projections may be formed in different ways, according to whether their external appearance is to be proportionately high or low and if a separate window sill be arranged, this with the base-member, may be changed into a second base above the cap of the base proper. Many special solutions may be deduced from the internal requirements, a few specimens of which are given in Figs. 343, 348, 350.

In palaces and public buildings, the base assumes a greater importance and a stronger expression. It projects considerably as a seat in a few Florentine palaces. The bases of churches generally require a strong projections to correspond to their considerable height.

In cities, where dwellings are found in cellars, the base often has a considerable height to afford a greater height of windows. It is not possible to go itno the endless ways of forming the bases of buildings. There sometimes exist diversities in the ground, peculiar dispositions of plan, connection of base with principal entrance, with terraces or external steps.

steps, which leads to special arrangements. Projections of the masonry, columns, pilasters, with or without pedestals, influence the form of the base, together with rusticated masonry which is much used for the base; further, cellar and sub-cellar windows, etc., windows of church crypts, etc. The base will always be modified according to the form, arrangement and proportions of the windows of the basement story. A considerable influence also results from whether the spaces beneath the windows project or are recessed behind the wall-face. Also from the arrangement of shops, whose large show windows render a low base desirable.

A base will often be proper in the principal story, and then usually has a slight projection and consists of a plinth, and a flat or moulded, decorated band, whose height corresponds to that of the window sills.

Flush or slightly projecting string courses with upper and lower members may appropriately be used at the height of the window sills and caps, at the ears in rectangular, or the height of the springing of arches over round-headed windows; they subdivide the stories in smaller divisions, connect together the windows of a story, and may be desirable for producing an animated division of the wall.

b. String Courses.

These are sometimes used for separating the stories. The principal story, at least, must be separated from that next below by a string course, or from that above, if it is itself the basement story. Whether all the stories should be separated by string courses or not will depend on their number and character, as well as the length of the building. If a 'ruled appearance of the building is to be avoided in four or five story buildings, perhaps only the basement story with the mezzanine may be separated from the principal story by a string course, and the upper story divided from those below it in the same way.

The forms of string courses should be as different as possible from those of the cornice; they should therefore have no more projection than may be necessary, so as to not conceal the lower part of the next story by their projection. The larger string courses, which separate the principal story from that next below, usually consist of a geison with water drip and upper and lower mouldings, Fig. 386. The string course will appear heavier or lighter, according to the prominence of the geison and the forms of the members. It is enriched and strengthened by the introduction of dentils. The string course must always have a wash to lead off the water, with or without a cove, by which the effective height of the course may be ba

reduced. In richer designs, the string course may be separated from the wall by a frieze above a bordering member.

The string courses of the other stories must be kept less prominent and be profiled differently from the principal one, either by increasing the upper and lower members, to diminish the height of the facia, by replacing this by a quarter round or cove, or by forming the string course at pleasure, composing it from proper elementary forms in a suitable way, Fig. 387 These string courses may also be combined with a frieze.

To decorate separate parts of string courses by the expedients of antique architecture would not be normal in stone construction and for houses on account of the expense. It is essential that it should look well without decorative accessories. This luxury may be allowed in public buildings, palaces and churches, and the principal stress is to be laid on the fact, that these ornaments contribute to the effect; therefore with plain building materials under weak northern sunlight, and with darkening of stone by abundant coal smoke, we shall do well not to lose ourselves in the delicacy of Greek ornaments, but to adhere more closely to the severer forms of Roman and Renaissance as models. As we have neither Greek proportions, strong light, nor noble marble, we must make allowances for conditions entirely different.

c. Cornices.

The main cornice has the material purpose of protecting masonry from rain as much as possible, and of receiving a gutter, as well as the ideal one of terminating and crowning the top of the building. The height of the cornice depends on the effect to be produced and its projection, or how far the material employed may freely project. The higher the cornice, the lower will the building appear in proportion, and the lower it is the higher the building will seem to be. The fewer the number of stories in a building, the less the necessity for the cornice to appear high. The cornices of low buildings should then be proportionally high, and of high ones, low. The following Italian Renaissance buildings may serve as guides. The height of the cornice without frieze, measured from bottom of lowest to top of highest member, is as follows, in terms of the total height of the building. Villa Farnesina, 1-20; Pandolphini Palace, 1-16; Gondi Palace, 1-18. The entire entablature, including frieze and architrave is 1-21 of the total height in the Cancellaria, Rome; 1-16 in the Rucellai Palace; 1-8 in the Villa Farnesina and Pandolphini Palace; about 2-13 in the Library of St. Mark at Venice; 1-9 in Bevilacqua Palace, Verona.

In modern buildings of the Dresden school, the cornice, including frieze and architrave, measures about 1-17 of total

height of building, [illegible], omitting frieze and architrave. Other schools of Architecture employ bolder cornices; those of the Dresden school have an elegant and refined effect without appearing too small. Gnauth obtained good proportions in two palaces at Stuttgard with 1-10 to 1-12, inclusive of frieze and architrave, or 1-25 to 1-27 without them. (A common American rule for 1 or 2 story buildings is to make total height of entablature 1-12 of height of its top from ground level, but this is too much for taller buildings.) No fixed normal proportions for height of cornices exist, only starting points at most being given, for these proportions depend on those of the entire building and its absolute height, as well as the point of view. They must be left to artistic feeling in each case, and the maximum possible distance between the eye and building also influences the cornice. Genoa is characteristic in this respect, with its narrow streets, tall palaces, and high string courses and cornices.

The projection of the cornice is determined first by its construction. If the projection and height are equal to h, Fig. 388, the area of the cross section is about 1-2 h X h, so far as it projects from the wall; hence the block of stone must extend at least as far into the wall as half its height. (An American rule is to make each stone extend into the wall as far as it projects). The more the projection exceeds the height, the further must the block extend into the wall. From this the following principles are derived. 1, Material is saved by a small projection; 2, in greater projections, the stone should be hollowed-out as much as possible; 3, the cost increases with both increase in projection and height.

If a larger cornice is to be composed of several blocks of stone, attention must be paid to equilibrium of the overhanging parts with those built into the wall, and it may happen that the cornice projects as far behind the face of the wall as in front of it, when all the blocks are fastened together by clamps, Fig. 389, or at least enough to make the area of the shaded portion in Fig. 390 greater than that of the part not shaded. From this discussion it results that to continue the wall in form of an attic is preferable, to bring the centre of gravity of the cornice as near as possible to the axis of the wall. That it is also desirable to lighten the cornice as much as possible by modillions, dentils and ornamented mouldings. But it is to be noted that the modillions must not be cut from the same block as the geison, but separately arranged as the geison would otherwise be too heavy and the purpose of the modillions entirely lost. Thus the mutules and their guttae of the Doric style are objectionable as being otherwise, and it

and it would be better to treat the under side of the geison with sunken coffers. Dentils, by which cornices are made lighter and more animated, are useless when their projection is slight, and are therefore best omitted in string-courses or cornices of small projection.

In its simplest form, a cornice now consists of three elements; the strongly projecting geison, the supporting lower members, and the crowning upper members, Fig. 391. The geison is hollowed out on its under side to form a water drip. If, as in Grecian architecture, the corona also forms a gutter, this must be much higher than the geison and therefore becomes a dominating motive, and to not unnecessarily increase the weight a steep and slightly projecting profile is given to it, Fig. 392. But the geison usually predominates and the crowning member is best worked from the same block as the geison and not from a separate one, as if an actual gutter is used. In richer forms, weaker members are inserted between the cyma and the geison.

By our method of working all cut stone from rectangular blocks, it is absolutely necessary to retain the horizontal joint a f close beneath the geison, Fig. 393. If it be desired to panel the under surface of the geison in coffers, the drip should be short and bordered panels should be inserted between it and the supporting lower members, Fig. 394, plan & section.

The readiest expedient for enriching and strengthening the cornice is the insertion of a second projection between the supporting lower members, increasing these members, Fig. 394. This second projection is preferably formed as dentils, Fig. 394. Between it and the geison are placed modillions in still richer cornices, around which are broken the upper members of this course. In the richest cornices a group of members is placed beneath this row of modillions, and even another projection with its upper and lower members. A frieze and even an architrave is placed below the cornice whenever required by esthetic needs. The frieze may remain flat or may be decorated, Fig. 394 a, or it may be formed as a series of vertical modillions, as in a fine example by Vignola, which permits a still greater projection of the cornice.

All modern cornices are merely variations of this motive, already fixed by the classic and Renaissance styles; the question is then whether one will adhere more or less closely to Grecian, Roman or Renaissance architecture; whether one will strictly retain the columnar orders or not, and whether the cornice shall be ornamented or not, and in what way. The architrave may be made lower in facades, being entirely built into the wall than when used over colonnades or porticoes, which

require the stones to possess a certain strength.

d. Interruptions of Cornices.

A peculiar conflict arises if the centre or end portions of a facade in three divisions are made higher. If the cornice of the lower portions is carried across the entire facade, a principal cornice will either be partly used as a string-course which is unseemly; or the higher part must be made to project sufficiently for the cornice of the lower part to abut against it, Fig. 395 a, b. It will then be preferable to so adjust this that a portion of the cornice of the lower part of the building may be changed to a string-course for the higher part Fig. 395 c. Or the string course of the higher portion is broken around and unites with the cornice of the lower one, Fig. 395 d. To let the cornice of the lower part simply abut against the projection of the higher part, as in Grecian architecture and as done in our era by the advocates of this style, is and remains a faulty expedient of an undeveloped art. The architecture should at least be so arranged, that at the height of the architrave of the lower building, a slightly projecting band extends around the higher part to preserve continuous lines and to properly connect the parts, Fig. 396. If one follows the principles of Grecian architecture in such cases, he will be only too likely to employ two different scales, which is usually happily avoided in the Renaissance.

3. Stories not separated by horizontal Members.

Instead of separating the stories by string-courses, it is sometimes customary to carry the masonry unbroken from base to cornice, dividing up the wall by projecting pilasters or projections, thus forming vertical divisions; even columns, extending from base to cornice, are used in this way. Although a powerful effect may be thus produced, the arrangement contains an internal contradiction. It is always more natural to allow horizontal lines to dominate, and even if vertical projections of the wall are arranged in form of pilasters, etc., no reason exists for suppressing the horizontal members, which may either stop against the vertical projections or be broken around them. Even Gothic church architecture made vertical lines dominant, but never suppressed horizontal divisions, and treated them the more boldly where they were justifiable.

4. Galleries, Balconies, Verandahs, Bay-windows, etc

a. Galleries, Balconies, Verandahs.

Halls, whether intended for churches or for secular purposes frequently have galleries on one or more sides. When narrow, these may be formed by corbelling out beams of stone, wood or iron, that support the architrave or the floor; but to appear strong, they require to be supported by consoles, corbels, etc. Galleries

Galleries, several of which may be placed above each other, are either vaulted or not, open towards the hall, and rest on arcades or colonnades. They have solid or perforated balustrades in front, and may be treated like a series of connected windows. These galleries become porticoes, loggias and verandahs on the exterior of a building. Those intended for enjoyment of fresh air and fine views may be arranged in houses, as well as public buildings. If covered, the lighting of the room behind them is always impaired when it is lighted by windows. A construction as light as possible with slender supports and with numerous openings is therefore desirable, and the general character will thereby be determined, and it will pleasantly contrast with the more solid facade, which is broken or united by the portico.

b. Bay Windows and Balconies.

Bay windows and balconies are external rooms constructed by corbelling out the walls. They may also be added to the walls of cities and fortifications, terraces of chateaux, towers, etc. They are always occupied rooms, obtained by projections, are crowned by balustrades and supported by corbels, consoles, etc.

The ordinary balcony is generally a single stone slab supported by consoles or corbels, whose thickness is about the same as that of a string-course, its edge being moulded like that of the string-course. The thickness of this slab depends on the material, on the projection of the balcony, and on its loading by people, who may be on it. Its under side may be decorated by panels of any kind, provided that they do not wek weaken it. It may project considerably beyond the consoles. If all unnecessary weight of the balcony is to be avoided, open balustrades of wrought iron are preferable to solid ones of stone or masonry; wrought iron rods and ornaments, as in balustrades of stairs, must be placed so near together, that a child's head cannot be passed through, so not over 7 1-2 in. apart. The height of the balustrade should seldom be less than 3 ft, also true of balustrades in general. Balustrades of balconies and galleries are also constructed of perforated slabs of stone let into angle-posts and covered by caps. These caps may have profiles like those of window sills and should be at the same height.

Balustrades of perforated stone-work are very pleasing in connection with decorations of wrought iron. Since the Renaissance period, balustrades composed of short, vase-like supports have been and will remain in use. The spaces between these may be filled with ornaments of wrought iron, which produce a very good effect. Balustrades of bay-windows of living rooms and of halls of all kinds should be solid. If it is de-

desired to [illegible] solid panel must be placed behind them. Bay windows have a pleasing effect in connection with the entrance door, giving rise to many peculiar arrangements. Angles of corner houses are especially favorable places for bay windows. Hence these windows may vary greatly in form of plan, being oblong, square, circular, etc.

5. Stairs.

We have chiefly to consider their forms and not their construction. As for arrangement, they are straight or winding. The steps may be supported by a string at one end, or this may be omitted; they may be supported by vaults or by small colums or piers, which may form a system of tracery. The balustrade and hand rail enclose the stairs on their open side; the under sides of the landings often influence the effect of the design and also the newells, against which the hand rail usually abut

a. Stairs with and without Carriages.

If the steps lie on each other and support each other without a carriage, their ends and under sides may be decorated by panels of very varied forms. If strings are used, these may be simply inclined at the rise of the steps, they may be formed in steps on their upper edges, or steps may alternate with inclined portions, Fig. 397. These htree arrangements will be more or less suitable, according to the arrangement of the balustrade. A moulded upper edge and moulded under side of the string will have a pleasing effect. The strings may also be so treated as to form a series of console-like supports, F. 398.

b. Stairs vaulted beneath.

Stairs are often vaulted underneath and the most different kinds of vaults may be thus used. Stairs with steps built into the walls at each end give rise to a very pleasing arrangement by constructing an arch under each step, so that the vaul itself ascends in a stepped form. The same principle produces peculiar but pleasing forms in case of winding stairs, and which are especially adapted to brick construction. One of the most pleasing kinds of stairs is that in which four strai straight flights run around a square well; if the stairs and landings are then supported by groined vaults, these are alternately inclined and horizontal, producing very varied forms of ceilings. One of the finest motives for the treatment of stairs was an especial favorite in mediaeval church architecture, and is that with steps supported by small columns or pillars. If these are changed into tracery, they lead to the most varied forms, suitable for small stairs, especially such as are used in houses, within the rooms themselves, or in church architecture.

c. Balustrades of Stairs.

The balustrades of stairs are of stone or iron (or wood in the U.S.). If made of stone, the hand rail is supported by balusters, though small columns or pillars are also favorites. Or perforated slabs are arranged, either decorated by free ornaments or formed as tracery in strictly geometrical patterns. Balustrades of wrought iron are especially suitable, which consist of vertical decorated bars or of free scroll work. Cast iron and bronze may also be used, though cast iron will seldom be employed for balusters on account of its brittleness, and bronze is so costly that stone or wrought iron will be preferred. Cast zinc is very suitable for the interiors of buildings but requires to be painted or gilded on account of its unpleasant color. Wooden balustrades should only be used for wooden stairs, and may be composed of separate wooden pieces or be actual carvings in wood. Wrought iron balustrades are also suitable for wooden stairs. (Wooden platform stairs with wooden newells and balustrades are most common now in the U.S.).

d. Angle Newells of Stairs.

The angle newells, agains which abut the baulstrades, the hand rails, and the herings, afford opportunity for the most varied treatment. Care must always be taken to have the parts named join the newells in a natural and proper manner. The newells may support a gas candelabrum, a vase of flowers, a decorative figure, or one supporting a coat of arms, etc. Their forms are treated in accordance with the special case in which they are used, with their arrangement, and with the material of which they are constructed. They always require a plinth, a cap, and frequently a crowning ornament; the forms of the plinth and cap should harmonize with those of the carriage and hand rail, with which they may or may not be connected. (Generally terminate in a turned drop at lower end).

e. Landing Slabs.

Care must be taken to secure a pleasing treatment of the under side of the landing slab, if it is not concealed by vaults Shallow panels are suitable, so as not to weaken it, their maximum depth depending on the thickness and clear span of the slab, and on the particular case in which it is used. If many persons use the stairs of buildings at certain hours, as in schools, theatres, concert halls, etc., it may become dangerous to weaken the landings. Therefore this panelling must be carefully considered in each special case.

f. Winding Stairs.

The under sides of the steps of winding stairs are either left flat, or are dressed off to a helicoidal surface, or a vault is constructed beneath them. In the first case, wedge-

shaped

shaped prisms are formed, whose edges are moulded, or their surfaces may be decorated by sunken panels. In the second, the helicoidal surface may be ornamented by panels, mouldings or ornaments, arranged with reference to a helical line, the decoration may be radially arranged, or a combination of the two may be used. A vault beneath winding stairs may be divided in radial compartments, or may be an ascending, annular, helicoidal vault, the last permitting pretty treatment in brick construction by the aid of decorative bonds, especial favorites in Dutch brick architecture.

If the newell of winding stairs be solid, it should have a hand-rail moulding, Fig. 399, of such form as to be easily grasped and therefore usually a round between two hollows. A central well-hole instead of a newell should generally be enclosed by an ascending helical string-like member, moulded or decorated, and worked in the solid on the ends of the steps. In larger winding stairs, this should be supported by small columns, very beautiful examples of these being in the Castle of Meissen and the Woman's House at Strasburg. Very grand winding stairs should have a staircase for servants instead of a newell, which may be lighted by windows, obtaining opportunity for ornamenting the walls of the stairs by niches, tracery, etc

6. Towers.

Towers are either intended for staircases, for observation, or for bells, and in all these cases have an upper story, essentially different from the lower stories; the upper landing of staircase towers is lighted by a window, as well as the entrance to the attic story or to any other room. Towers for observation or fortifications serve for temporary or permanent occupation. Bell towers contain a room for the bells. Church towers are either detached, joined, placed over the intersection, or are small towers on gables, the latter being also employed for signal bells, clocks, etc., as in hospitals, barracks, etc. Town halls in particular, among secular buildings require a clock or bell tower; towers are also frequently necessary for prisons, city gates, bridges, chateaux, fortresses.

a. Plans of Towers.

Towers are either free on three sides, projecting from the line of the building, or are built in and free on two sides or but a single one. The square plan is preferable, but it may also be circular or polygonal, with any number of sides, its form being decided by its purpose, and by the place at which it is to be joined to the building. Detached towers are seldom placed near a building, except when independent, but may be so arranged as to be partially free, as when connected with the lower story of the building by an arch, above this being

entirely separate from it.

Staircase towers should always be attached at one side or stand in the angle of a building. They should generally be simply treated, being subordinate parts of the building, shoud have small windows, only their upper stories being richer and with large windows. If they play a more important part, their openings should be more numerous, and they should be lighted by larger windows. In many cases, a gallery supported by corbelling or other supports extends around them at the height of one or more landings. The string courses should be oblique in accordance with the inclination of the steps, or should be arranged in angularly ascending steps, or may be horizontal and placed at the same heights as the floors and the window projections. Either arrangement is used according to the case.

Towers may also be bay-window towers, projecting from the building on each floor and containing a room like a bay-window. This is a favorite in chateaux, fortresses, town halls, etc.

b. Towers for Observation.

These may be entirely free or adjoined, and may partly contain staircases, the uppermost parts being furnished with galleries, balconies, and similar expedients for facilitating observation. Church towers are frequently towers for observation especially when serving as stations for fire-watchmen, and then have a special story fitted up as a dwelling for the watchman, where the watch is kept at night. Such a story produces a special effect on the entire tower.

c. Bell Towers.

These are essential requisites for churches. Their most important portion is a room for the bells, with as large or as many openings as possible, that the sound of the bells may go to a great distance. Church towers are usually intended for various purposes. They may contain a vestibule in the lower story, an organ gallery in the first, a room for the clock in the second, a room for bells in the third, and one for the watchman in the fourth, which would require five stories of different heights, and which should be differently characterized. In contrast to the open story containing the bells, the other stories are to be as nearly closed as possible, avoiding unnecessary openings. In churches with nave and transepts, the intersection gives opportunity for a large tower to serve as a bell tower or to admit light to the intersection. In either case, it may have as many and as large open ings as possible.

Town halls should often have a tower, whose lower portion may contain a room for archives, an open balcony, etc., while in its upper portion may perhaps be arranged a clock, bells for striking the hour

for striking the hour and a room for a watchman. It also often contains the city prison. Its form should therefore be varied according to circumstances, but being a tower for secular purposes, all ecclesiastical character should always be avoided. This is true of towers of prisons, city gates, bridges, chateaux and fortresses. A fortress-like character is more suitable those, with decoration by battlements, bays, and similar expedients for producing a picturesque effect.

d. Roofs of Towers.

The most essential factor in the treatment of the tower is the roof; towers may have wooden roofs, stone spires, or iron roofs; these may terminate with domical, pyramidal or conical forms, or a crowning form may be produced by combining these. The treatment of the roofs of towers is in all cases one of the most fruitful and welcome probelms for the Architect. The elements available for the purpose are: 1, open galleries with columns; 2, low open arcades; 3, dormer windows; 4, placing masses at the angles; 5, forms of gables; 6, several galleries above each other; 7, the roof itself, whether a dome, a hip or a conical roof; 8, corbelled-out bay windows, balconies and balustraded galleries; 9, gargoyles, finials of all kinds, weather cocks, crosses, and other ornaments for the apexes of towers. The most varied treatment results from combining these.

Chapter 19. Roofs.

Roofs are generally of decisive importance in the external effect of buildings as they materially aid in forming their visible outlines. Sound artistic feeling therefore led the Greeks, no less than mediaeval masters, to lay the greatest stress on the treatment of the roof. Less attention was paid to its forms by Renaissance masters, with the exception of the domed roofs of churches, and this tendency of the Renaissance is now the aim of many architects, to allow the roof the least possible part in the effect of the building by concealing it behind an attic, or by making it so flat that it is invisible. A rational development of the roof is missed less in Italy, where wood is not abundant and snow is hardly seen, so that flat roofs are not only appropriate but actually required by economy. It is otherwise in the North with its abundant wood and snow. The northern nature requires the perpendicular lines of our buildings to be emphasized by the roofs; in our country with its forests, cities would seem to have been burned if the buildings were without their very effective roofs, with all their accessories of dormer windows, chimneys, etc. Care must then be taken that roofs are artistically treated so as to improve the general effect and not disturb it. It shoud

not seem that the Architectcannot design anything above the main cornice. Magnificent buildings, like the former Court Theatre in Dresden, require something more than a formless and gigantic roof with two lightning rods. Amid its animated surroundings, with the outlines of the Court Church and of the Palace with its tower, the heavy mass of the old Theatre appeared very badly. Among the many noble buildings on the Ring Street in Vienna, the Town hall with its well developed roofs appears far more advantageously than the New Museums, which look as ifethey had been burned.

We will next treat in detail the following: 1, the batter of walls; 2, forms of roofs; 3, The roof covering; 4, dormer windows; 5, ridge-towers; 6, Chimneys; 7, decorations of roofs; 8, gables or pediments.

1. The Batter of Walls.

Enclosing walls are properly battered, that the rain water may flow off on that side where least injurious, usually the exterior next the street, where means of carrying off the water are usually provided. It is then proper to add a drip to the battering side of the wall. The same is true for battlements. If it be required to prevent passing over the wall, a cresting or wrought iron lattice-work will be proper and may be of very pleasing form. It will also sometimes be necessary to give the top of the wall a richer form, to make separate parts of different heights, and to animate the wall by means of windows, vases of flowers, as well as iron lattices and similar expedients.

2. Forms of Roofs.

The principal forms of roofs are the shed roof, hip roof, gable roof and pyramidal hip roof. Composite forms may be used as required. Thus a gable roof may be hipped at both ends, or a gable or hip roof may join another gable or hip roof, a favorite form for the roofs of towers. Inclinations of roofs will frequently vary, to produce a better effect, that the e ends of a hip roof may be steeper than its sides, etc.

It now frequently becomes necessary to employ the mansard roof and the curved mansard for angle pavilions of public buildings. These forms are quite appropriate where required. For economy, it may frequently become necessary to lessen the height of the roof by placing a deck roof above an inclined one. For esthetic reasons, roofs composed of curved surfaces should also be used, as for angle pavilions and conservatories

Proportions and forms of roofs are always to be so chosen as to add to the effect of the building. If a space for passage be arranged above the main cornice with balustrades, this should never exceed 3 1-4 to 3 1-2 ft. in height; high balustrades

trades make the building appear low, low ones high. Balustrades can scarcely be lower than 3 ft., as their purpose would not then be fulfilled. If these balustrades are arranged in connection with pedestals supporting statues, these must be so designed as to produce a suitable sky-line.

3. The Roof Covering.

Care must be taken that the roof covering not only fulfils its purpose, but also has a pleasing effect. Even thatched straw roofs may be made pleasing by the mode in which the bundles of straw are fastened. The roof coverings of rustic buildings usually have a picturesque effect; sometimes consisting of stone slabs of irregular form, when plates of porphyry or thin slabs of Jura limestone are used; sometimes of shingles held down by stones. Moss and all kinds of plants, which grow on roofs, frequently appear very picturesque, although not very beneficial to wood-work. By cutting the lower ends of the shingles, many kinds of patterns are formed on shingle roofs, but care is necessary that the shingles be of such forms that the water may be kept as far away from the joints as possible. Tile roofs take various forms when the vertical joints are continuous or alternate, when the tiles are set in bond or not. Their forms further depend on the forms of the lower ends of the tiles, as well as whether tiles of any special patterns are used.

The ridge and eaves of the roof always require special precautions to prevent entrance of water and to properly remove it. These parts also first require decoration, whatever the covering of the roof may be. Borders of tiles of different color should then be arranged along the upper and lower edges of tile roofs in patterns of all kinds, with ridge tiles of special forms or suitable finials at the apex of the roof.

In slate roofs, the most picturesque effect is obtained by laying the slates in diagonal courses on close sheathing. By using slates cut to certain forms, the most varied surface patterns are produced, which may be enhanced by slates of different colors. Borders along the ridge and eaves and bands around dormer windows are always decorations peculiarly appropriate for roof surfaces. The ridges of slate roofs are most suitably covered with metal, and crestings of perforated plates, or hammered work, of cast lead and zinc, or of wrought iron, are always proper, as well as finials of those metals on the ridges of roofs.

4. Dormer Windows.

A kind of story is often arranged in the roof, especially in mansard roofs, and lighted by large windows. These may be very richly and decoratively treated, and generally consist of

an architrave between pilasters, which support an entablature and a pediment, and its base can be made wider by volute-like additions at each side, Fig. 400 a, b, c, d; Fig. 401 a, b, c; They may then be properly grouped with the second story windws
Large dormer windows are sometimes required for hoisting weights by a crane, when in a ware-house. They then receive a strongly projecting roof, in which the crane is fixed, and are closed by wooden shutters, which may be decorated by bands of wrought iron. Dormer windows generally serve to light and ventilate the arttic; they may be decorated by ornamental gable roofs or left quite plain. Wooden gable roofs of church spires are frequently decorative expedients of chief importanc and may be connected together, to facilitate fastening the ropes required for the slater's work. The dormer windows of houses and of public buildings may be circular, semicircular or elliptical, or may be of the most varied forms. They should have an architrave and some form of cresting, which is frequently made of sheet zinc. Dormer and roof windows always add much to the decorative effect of a building.

5. Chimneys.

In a fully developed architectural style, one must not forget to give the chimneys a pleasing form, and to so arrange them that the general effect of the building may not be injured. They should then have bases, with caps at top for the discharge of smoke. The form of this cap always depends on its special mode of construction. It is proper to give the chimney a twisted form and to unite several chimneys in a group, covering the whole by a roof of thin metal to keep out rain. This roof may be pleasingly treated in various ways, be decorated by small gables, or be formed like a crown.

6. Decorations of Roofs.

Among the decorations of roofs, the cresting is here specially considered, and may be executed in wrought iron, cast zinc, or hammered sheet copper, and is generally arranged as a cresting on the ridge of the roof; the finials are of the same materials, in the form of sprays of flowers, weather cocks, crosses, animals and all other forms, and decorate the angles of roofs and especially towers. Few general principles may be laid down for these crestings and finials, the greatest freedom in their treatment being admissible. They produce the most pleasing effect if partly painted black, partly gilded, and by their open appearance afford the most beneficial contrast to the massive character of the roof surfaces.

7. The Pediment or Gable.

Pediments or gables form the end surfaces of gable roofs. They are either closed, as in antique temples, and decorated

by ornamental sculptures, or they are penetrated by windows of circular or other form, which light the interior of the roof; they may further be closed by an open staircase, one long side of the building being connected with the other, as in some Romanesque churches. In houses and palaces, they frequently contain one or more rooms, and then have windows; they are sometimes decorated in the richest manner and divided into several stories. Their outlines consist of the two inclined lines of the same inclination as the roof, or these are stepped to appear to form battlements; from the last were derived the richly decorated gables of the German Renaissance, with ornamental accessories of all kinds.

The most antural mode of decoration is to make the two ends and the centre most prominent by acroteria and sculptured decorations; all modes of loading the ends heighten the apparent stability, although seldom really increasing it, and the acroteria at the centre satisfies an esthetic need. In very high gables, as those of churches, these free-ending forms require considerably proportionate height; gable crosses, finials, figures, and similar motives may then be employed. The gable is covered by a cornice, that may sometimes be decorated by crockets, like Gothic, or it may be resolved into free and fanciful forms, as in German Renaissance. Both arrangements are proper the first being most suitable for buildings of earnest and dignified appearance, churches, museums, opera houses, etc.; the second, for those intended to have a character of greater magnificence, as chateaux, theatres, comic operas, etc.

Chapter 20. Construction in Various Materials.

1. Stone Construction.

This is the most monumental and worthy expression of Architecture, and at the same time is the most expensive mode of construction. The true historical development of Architecture was worked out in stone construction; construction in brick and wood only approximated in other materials to the forms and motives already existing in stone construction. It is indeed true that in various places, stone construction was first developed fromwood construction, borrowing thence most of its forms, as the entablature, the columns, and the gable roof; but the further development of these and other elements first took place in stone construction, as well as the fixing of esthetic proportions. The resistance of stone to crushing and transverse strain prescribed the limits within which stone construction could be used; resistance to tentics seldom comes in consideration, except as it may occur in a beam under transverse strain. The elements of stone construction are always

monolithic beams of stone, pillars, slabs, ashlars and voussoirs. All architectural construction is arranged with reference to these. Although a greater firmness is given to stone construction by the use of mortar, it must itself be so arranged that the different parts of the structure are in stable equilibrium. It is always characteristic of stone construction that the elements of its structure are always within certain limits, depending on the thickness of the layers of the stone as quarried, that considerable projection of the cornices is possible, and that the mode of cutting also aids in the effect.

The use of different qualities of stone may strongly characterize stone construction. Harder stones should then be used for the structural portions, and softer ones for the masses of the walls. The water tables, string courses and cornices, architraves of openings in walls, supports, and the remaining cut stone work, will be clearly distinguished from the masonry proper. This is also true for walls plastered externally, or if stones of equal hardness and strength but of different colors, like red and white sandstone, are employed in a structure. The rarer kinds of stone should then be used for architectural details proper and the more common kind for the masonry. This further depends on the ease of working the stone and the texture of the material. If two kinds of stone are of equal hardness, one must then decide in accordance with the character of the building, which of the two shall predominate. Red sandstone in mass gives the building an earnest, gloomy character; white imparts a cheerful and brighter one. Darker stone requires coarser forms than lighter stone.

2. Brick Construction.

The character of brick construction is determined by the small dimensions of the elements, by the intimate connection of the mass, and by the slight projection of string courses and cornices. It therefore always produces works, which are massive, have small members and proportionally slight relief. Two styles have been developed in brick construction, the northern mediaeval brick architecture of the low northern plains with the allied Bavarian and Dutch, and the brick architecture of Upper Italy. The first may be termed brick architecture with moulded bricks, the second, that employing terra cotta. The northern style seldom used terra cotta, great favorite in that of Upper Italy. Both styles lead to peculiar forms and both may be combined, or are already combined in the brick architecture of Upper Italy, this style using both moulded bricks and terra cotta. The difference between moulded brick and terra cotta consists in this, that the latter [illegible] cast or pressed in moulds, and therefore admits of that [illegible]

broad forms, such as portions of friezes and freely modelled sculptured ornaments, while moulded bricks are properly only profiled bricks, so that the first style omits nearly all ornamental and sculptured decoration, but uses enamelled and colored bricks and sometimes ornamental blocks carved from sundried clay and afterwards burned.

However pleasing the works of northern mediaeval and of Lombard or Sienese brick architecture, with our improved conditions of transportation, a pure brick architecture, omitting all cut stone, is now only advisable in certain localities. Where cut stone may be readily obtained, it will usually be preferred to bricks, these being used only for the simple masonry.

3. Mixed Stone and Brick Construction.

Where brick is the ordinary building material, and sufficient cut stone may be obtained for the principal architectural details, a mixed stone and brick construction will be used, like that commonly found in the Netherlands and there developed in a peculiar way. All string courses and cornices are there made of cut stone, a block of stone being built in at the doors and windows, wherever iron anchors are to be fixed for wooden door or window frames..

In a more developed form of mixed stone and brick construction, the brick-work is entirely limited to the masonry or wall, the jambs of doors and windows and all other structural parts being of cut stone. But projections for strengthening the wall may be built of brick on account of its stronger bond, while their capitals and bases are of cut stone. In isolated piers, it is best to interrupt the brick masonry at regular intervals by cut bond stones to give them greater strength.

The mixed stone and brick architecture of many Dutch buildings of the Middle Ages and Renaissance is quite refined, and there is in it a certain intention of producing a special effect by contrast of colors of white sandstone and deep red bricks. No opportunity is lost for decorating springing and key stones, or for interrupting brick masonry by courses of cut stone, placed at the same height as the window sills or transoms, Fig. 402, the brick masonry forming closed panels. These expedients give the mixed stone and brick architecture of Holland its peculiar effect, and form the most simple and ready general means of obtaining a good effect economically.

4. Wood Construction.

In wood construction, since the resistance of the material to compression, transverse strain, and tension, is exerted, elementary structural forms result, entirely different from those used in stone construction. Horizontal timbers under

transverse strain are Beams, Sills, Purlines and Girts. Vertical supports are Posts, inclined ones being Struts and Braces, all subject to compression. Horizontal timbers subject to tension are Tie-beams, vertical ones being King or Queen Posts. The most fully developed wooden architecture known to us, is that of Swiss and Tyrolese houses, the former being preferably built of logs, the latter having a timber frame lined inside. The strongly projecting gable roof, the open galleries, the low stories with their numerous windows, lend to these wooden houses their characteristic appearance, that varies greatly in each building by means of carved work of all kinds, owing to the abundance of wood in Alpine countries.

German wooden architecture chiefly used half-timbered work, interspaces being usually filled with brick-work; a projection of each story beyond that next below and steep gable roofs characterize these houses, better adapted to the North. These half-timbered buildings with interspaces filled with brick masonry, either plain or plastered, acquire a peculiarly pleasing effect when decorative brick bonds are employed.

5. Mixed Wood and Stone Construction.

The basement story frequently has a plain wall, especially if the upper story is half-timbered. The external appearance of the building then depends on the materials and the mode of construction employed, as well as on the painting, sgraffito, decorations in wrought-iron, overlays of tiles, etc. Neither pure wooden architecture nor mixed construction in stone and wood is suitable for monumental buildings, both being better adapted for rustic dwellings, modest city houses, etc.

This mixed style is well suited for small railway stations, forester's houses, country inns, for all structures attached to the drinking room at Baths and Spas, and a peculiar character should be given to these, corresponding to local conditions. This mixed style will also be used for temporary structures, for festivals, and for temporary purposes, after which they are to be removed.

6. Metallic Construction.

In this only buildings of wrought or cast iron require consideration. Bronze, on account of its cost, was seldom used, except in the [illegible] period, and then but exceptionally as a special structural material. But iron plays an important part in modern architectural construction. Its most extensive use occurs in railway stations, buildings for International Exhibitions, bridges and roof trusses. In accordance with the res[illegible] [illegible] po[illegible] of iron, all iron structures should have a character [illegible] thness, compression is principally resisted by [illegible] struts of cast or wrought iron, transverse strain

by wrought iron girders, and tension by wrought iron bars or rods. The walls and roofs are principally composed of thin plates, if not constructed of masonry or wood in combination with iron, or are glazed. The general character of lightness of iron buildings results from an endeavot for economy of material and labor, which requires each structural part to have the smallest possible dimensions. The stronger the construction, the less attention should be paid to its artistic appearance, and it should be left to produce its own effect. But in small structures, small view pavilions, garden houses, or rail way stations, care should be especially taken to decorate parts in cast iron, and also to use wrought iron ornaments of all kinds. The same is true for iron enclosing fences, latticed gates, monuments, canopies over wells, and similar objects. Perforated and hollow forms are suitable for cast iron, and for thin bars and plates of wrought iron.

7. Mixed Metallic, Stone, and Wood Construction.

A building may properly be constructed of stone, wood, and iron; as in very large rooms, the walls are built of masonry, while the roof is wholly or in part of iron, wood being employed for receiving the covering material. Each material is used in such buildings, the massive character of the masonry pleasingly contrasting with the light and graceful forms of the iron construction. Massive stone bridge portals thus have a better effect, than if made of cast iron, as the process of casting necessarily requires the avoidance of a massive character; buildings for Industiral Exhibitions, conservatories, and similar structures, are more pleasing if in part built of masonry, than if entirely constructed of galss and iron.

Chapter 21. Planning Buildings.

All modes of arranging the plan result from subdivision or addition, a given area of surface being either divided into parts, or such parts are arranged together.

A series of rooms are placed next the facade of a house, between two adjacent ones, the remaining apartments adjoining the former. In a detached dwelling or a villa, one commences with the largest apartments, the drawing-room or living-room, the other rooms being arranged with reference to these. In the first case, one designs from the front towards the rear of the site; in the second, one first groups the interior and then arranges the exterior. If the house occupies a corner, two series of rooms are arranged along its fronts, either placing the principal apartment at the angle, or this angle is divided into smaller rooms, just as may best accord with the requirements. A series of principal apartments should always be arranged

arranged along the chief facades of publicbuildings, if the structure does not contain a large hall, when the other rooms will be grouped around this. A corridor is often placed behind this series of chief apartments to make the rooms accessible. In public buildings the arrangement will therefore progress from front to rear, but in buildings containing halls, comprising theatres and churches, it will be from the interior to the exterior. To make the best use of the site, the plan is always to be so arranged, that the corridors may occupy as little space as possible; but in many buildings, like schools, the corridors not only serve as a means of access to the rooms but are also occupied by the pupils during intervals between classes, and by cases containing books, models, collections, etc., when they assume a greater importance, that influences the plan.

Space is always lost in vestibules, stairs, passages, etc.; one should therefore make this loss as small as possible, and in very large public buildings, the loss of time must also be considered, resulting from the connection of the different wings of the building by corridors, courts, etc. One should then arrange near each other rooms properly belonging together and make their communication more direct by private stairs, corridors, etc. One should also try to make vestibules, corridors, and courts as useful as possible, to serve for temporary occupancy by persons, and should therefore arrange light courts with glass roofs, galleries of all kinds, and loggias.

2. Sections of Buildings.

If the heights of stories are fixed, the cross sections of buildings are governed by the arrangement of the plan. The essential part of modern architecture concerning the section is this, that only in exceptional cases resulting from the form of the site or from special uses, is any floor not arranged throughout on the same level, as was the case in so many mediaeval buildings. Yet when peculiar arrangepents make it necessary, some halls are made lower or higher than the general height of the story, and must either extend below or above it. When the conditions of the site are peculiar, as in mountain cities or castles, the site usually produces very peculiar arrangements of stories, wherein should be utilized these conditions of the ground. It may then become necessary to abandon all rules and take into account the special case. But one should be careful to place as many rooms as possible on the same level, and to retain the heights of stories fixed upon.

3. Facades and Court-Facades.

The facade is essentially derived from the plan and the section. Openings for doors and windows, porticoes, loggias, tow-

towers, etc., chiefly determine the arrangement of the facade, the importance of the building, and the detail forms of the facade. It is required that the exterior results from the interior, and that it corresponds in every respect to the purpose of the structure, with which the selection of building materials and structural forms must be in strict accordance.

Facades towards courts are generally of a subordinate character; yet the courts are often developed into magnificent architectural works, and may be decorated by galleries, loggias, stairs and staircase towers, bay windows, balconies, porticoes, niches, fountains, or any other means of ornamentation. But a court must appear well from the most distant point of view possible, and according to whether the court encloses a garden or affords a fine view, its arrangement must be such as to utilize these advantages as fully as possible.

Chapter 22. Wells and Fountains.

Excepting monuments, the most beautiful and suitable decorations of public squares are wells and fountains. Market squares require cleanliness and therefore fountains, which are merely water outlets with a large tank, its centre occupied by a pedestal supporting a large shell, a canopy, a statue or group of statues, or a tower-like structure like the Schône Brunnen, Nuremberg. There are several other types of wells or fountains, such as : 1, the well, well-house, and the enclosed spring; 2, the running fountain; 3, spring wells and fountains; 4, cascades and other similar works.

1. Wells etc.

Wells are vertical circular shafts sunk to the water level in the earth, sometimes several hundred feet deep. They are furnished with a curb at top, an arrangement of some kind for raising the water, this being merely a bucket and chain, or pump, if the depth of the well is small. The well curb must be so formed that the full bucket may be set upon it, and its exterior may be decorated by reliefs. The finest examples of such curbs are the bronze ones in the court of the Doge's Palace, Venice, internally circular and externally octagonal.

The shaft of the well is even esthetically treated sometimes as a winding staircase with an open well-hole, in the lower part of this being a basin for collecting the water.

The bucket is generally suspended by a chain running over a pulley, which may be supported in any suitable way, a series of motives being produced and executed in various places. Sauvageot gives a beautiful well with two buckets supplying different levels, Fig. 411. Two piers of different heights support a horizontal stone beam strengthened at its centre by dee

decorations, where the pulley is fixed. Free terminals above the stone piers are added to ornament the stone beam. Wells of this kind are not rare in cloisters of Italian monasteries, are usually placed at the centre, and are raised several sets but they may also be attached to a wall into which is built the end of the beam, the other end being supported by a column Fig. 412. This motive may be turned to a good account by making the beam quite long and arranging so that one can pass around the well, Fig. 413. It will then be advisable to place a corbel between the beam and its supporting pillar. If the well is distant from the wall, the stone beam may be replaced by an iron bar let into the block supporting the pulley.

A further development of the well is produced by placing a strong covering slab above three or more pillars supporting the pulley. The centre of the covering slab may be strengthened, which originates the motive of accenting this centre by decorations, as well as by other ornaments placed above the pillars, statues, etc.; the German Renaissance produced many such wells, the motive even being improved by wrought iron work. This motive of the canopy well is developed in larger designs into a small polygonal structure, Fig. 414.

An example, though simpler than the one represented, is found near the Church at Veere, Holland, where rain water is collected on the roof of the church, led into a channel B running around the well, depositing there the impurities, while the purified water runs into the collecting basin A through the narrow slits, as shown in Fig. 415. The channel B and the tank A may be made accessible by winding steps. The pulley for the bucket chain is suspended from the keystone of the vault. In very deep wells the weight of the chain and buckets is too great for the chain to be simply drawn up by hand, a windlass then being substituted for the pulley, and supported by two bearings. A wheel is attached to the axle, turned by both hands, while the chain is wound up on the axle. The raising of water by machinery requires protection by a roof, that iron parts may be exposed to rust as little as possible. The well is then detached and covered by a protecting roof.

Well-houses are usually employed where a spring is treated like a well, placed under a roof, then enclosed to serve for drinking and to turn away the surface water. Mineral springs require special attention on both points. Where naturally hot water is obtained in such quantity as to be used for economical purposes as well as for drinking and baths, public fountains are usually arranged as niches in the walls, and the outlets for the water are closed by stop-cocks. Special drinking halls are generally planned, where the water is drunk.

Other designs for fountains are arranged like small open buildings, where water runs from one basin into another lower one, hence into a third, etc., to remove every vestige of impurity.

Larger designs for springs consist of an open basin with a channel for removing superfluous water and one descends to the basin from higher ground by a flight of steps.

Between wells and flowing fountains are pump-wells, which are seldom public wells, but are found in courts of private houses, and are seldom decorated. The well is then covered by a stone slab, at the center of which stands the usually wooden pump with swing handle, though the pump is also made of stone or of cast iron, then being treated like a stone pillar witha a cap and terminal ornament, or as a cast iron column with any form of capital, supporting a statue, a lamp, or terminal ornament. The pump handle may be decorated at its upper end by volute-like iron bands, to prevent its swinging sidewise. Below the spout, often treated like a rain spout in form of a lion's head, a dolphin's or dragon's head, etc., is the tank, most simply a hollowed stone block, but in more pleasing designs a vase-like basin resting on the base of the pump, and crossed at top by iron rods to receive the water pail, Fig. 416.

2. Running Fountains.

These chiefly differ from wells in being supplied by aqueducts or springs, the water being led through a system of pipes from a reservior higher than the outlet opening. They are either wall-fountains or detached fountains. The former are oten placed in courts and are niche-fountains, the front side of the tank projecting but little from the wall, Fig. 417. An architrave like that of a door decorates the niche, and this may be developed into a canopy with pilasters, columns, pediments, etc., while the front of the tank affords space for any form of decoration in relief. In circular niches, the upper part is decorated like a shell, a horizontal band being carried around it at the height of the springing, or the discharg pipe may be connected with a statue. The fountains in the courts of Italian palaces and sacristies of churches are mostly treated in accordance with the same principle, the tank being composed of, or covered with marble slabs, and sometimes cast in bronze. Another arrangement of wall fountains is to have the tank in front of the plane of the wall, making the niche shallow; this would be quite suitable for the angle of two streets meeting at an acute angle, Fig. 418.

A third arrangement, particularly adapted to be placed under landings of stairs or ramps, for terraces, aquaria or fish ponds, lighted from above, is to arrange a well-house as an

enlarged niche. These three modes may be varied in many ways and treated in accordance with the decoration of niche-fountains, they may be developed into grotto buildings of all kinds Imitations of stalactites, tufa, glittering minerals, shells, figures spouting water, dolphins and dragons, silenuses and centaurs, etc. serve to decorate such grotto designs.

The simplest form of detached fountain may be treated like pump-wells. In richer designs the number of water basins and discharge openings would be increased, and a corresponding form of plan selected, Fig. 420. The most varied forms are especially possible in larger market fountains, whether basins are placed in several tiers above each other, or a common basin is formed. The upper basin may also be accessible by means of steps, Fig. 421.

Various simple and combined polygonal forms, Fig. 422, may be employed to good advantage as such market fountains, and may vary according to whether they are connected with stairs, seats, or gas lamp-posts, or whether an upper group of water shells is formed in addition to the common tank.

As means of decorating these and other designs of fountains, all animal, plant, and purely decorative forms are suitable, if they have reference to water. The front side of the basin may have reliefs of all kinds; the central pillar of the fountain, Fig. 423, consists of a plain rectangular, circular or polygonal body a, mostly in the water, a second b contains the discharge pipes and may be decorated by inscriptions, coats of arms, reliefs, etc. Above this is placed a base c, its plan suited to that of the lower portion, and above a cap, this may bear a statue or group of statue, a canopy-like structure, or a lamp-post d. The upper basins may be formed as vessels or shells; care must be taken that they do not appear too massive when seen from below. It is a favorite idea for market fountains to add water-spouting statues in suitable places, even on the margin of the basin, to enclose the entire fountain by an iron grille, arranged that a pail may be filled. For this purpose, portions of the base may be corbelled out or openings may be formed in the grille at proper places.

3. Spring Fountains and Fountains.

These serve a purpose purely decorative and are only employed in gardens for obtaining water, and are connected with basins for gold fish or water plants. The simplest form consists of a vase-like shell on a pedestal; richer arrangements have several shells above each other, the lower fed by the upper. The whole may be surrounded by a single basin. The shells may be replaced by groups of shells, and the pedestals may be in form of short columns, a clustered pier, the lower part of a

vase, or figure sculptures. Discharge openings take the form of simple tubes, flowers, mouths of animals, or may be connected with figures. The greatest latitude is possible in the treatment of fountains. A rich contrast of falling and rising streams of water, overflowing shell-like basings, scrolled mouth-pieces at the discharge openings, sometimes give these a very fine effect. They may also consist of an islet in a basin, naturistically treated and decorated by statues supporting the water basins; it may further be enclosed by a canopy-like structure, or may decorate and cool the interior of room.

4. Cascade Fountains.

These are purely decorative and are architectural works, down which considerable volumes of water run. They may be purely architectural, like the Aqua Paola in Rome, where three great streams of water pour down from a gate-like structure in front of a triumphal arch, and flow into a collecting basin. Or in front of an architectural back-ground is constructed an arrangement of natural or artificial rock-work, from various parts of which water gushes forth into a great basin, as in the Fontana Trevi at Rome. Such cascade fountains may be developed greatly by sculptures and plant decorations in connection with buildings, flights of steps, bridges, grottoes, etc. The wall enclosing the basin may be formed as a seat, Fig. 424, its back having sufficient height, that a child standing on the seat cannot fall into the water; the coping may then be crowned by a low iron railing to prevent anyone from climbing over the enclosure of the basin.

Chapter 23. Monuments.

Besides fountains, the principal decorations of streets and squares are monuments, and we will consider memorial, but not sepulchral monuments. A distinction is also made in a monument between the object to be supported above the ground, the pedestal, and the base or foundation. According to the object supported by the pedestal, we may classify eight different kinds of isolated monuments.

1, The object consists of emblems, a cross, an obelisk, or a tower-like superstructure; 2, the pedestal supports a bust; 3, it supports a statue; 4, it supports two statues; 5, it supports an equestrian statue; 6, the principal figure stands on a pedestal surrounded by 4 or 8 subordinate statues; 7, the monument is surrounded by an architectural back-ground; 8, the monument is purely esthetic, its decoration by statues being subordinate.

There are two primary requirements for monuments of all kinds; they must have good proportions of mass, and if isolat-

ed

ed, their outlines must be pleasing. Both requirements are unfortunately seldom satisfied, the training of the sculptor not being sufficiently architectural, and he takes the advice of the Architect only when the idea of the composition has already been decided upon. It should be a first condition of an arrangement according to the plan, Fig. 425, that the statues at a should in some way be connected with the monument proper at b. In the Luther monument at Worms, all the statues look East, at right angles to the axis of the street, which has an unpleasing effect; the monument is also not at right angles to the street, but parallel to it, which must be considered a mistake, unless the monument is not placed in the middle of the street but stands at the side.

The proportions and the effect of the outlines will always be decided by the proportions between the pedestal and the object supported by the pedestal, which fixes its plan. If a cube rests on a slab and supports a pyramid, Fig. 426, the proportions of the masses viewed diagonally will be completely changed, and may perhaps be unpleasing; had we drawn a cylinder with height equal to its diameter supporting a cone, instead of the cube and pyramid, its appearance would be the same from any point. If we employ a form intermediate between the two, we have two choices of a form for the monument, either the octagon, or the cross, Fig. 427. Circular, octagonal, or cross-shaped pedestals always look best if viewed diagonally. It is preferable to make the pedestal of such form as to produce a gradual transition from the square to the cross, then to the octagon, and finally to the circle. If we insert a cap between the cube and the pyramid, Fig. 428, its projection will conceal a part of the pyramid and thus lessen the object supported by the pedestal. Being really the principal part of the monument, the pyramid should appear as large as possible, a special base then being given to it, whose mass is in a pleasing proportion to the mass of the pyramid. If the base be too massive, the pyramid looks small, and if too low, it does not appear as a mass. If an obelisk be made the principal part of the monument, Fig. 429, or a memorial column instead of a pyramid, the mass of the base would appear too unpleasing in proportion to the obelisk.

On this consideration is based the good and bad arrangement of monuments. The proportion between object and pedestal is therefore usually unpleasing, the pedestal being made too high and producing too massive an effect. It too frequently looks like a tile stove. It will then always be proper to insert a special base between the cap of the pedestal and the principal object of the monument, thus lessening the total height of the monument

monument by a substructure divided in several parts.

A second point requires notice, that the pedestal and the base of the object must be so arranged with reference to the object of the monument, to the treatment and the decorations in relief, that this object becomes the principal thing, or that a contrast is produced between the treatment of the base and the more or less detailed principal object or subject of the monument. An equestrian statue thus harmonizes with a richly treated base above a more simply formed pedestal; statues with rich drapery or richly detailed costumes, a standing or couching lion, a dragon-fight, etc. will require plain and simple bases and pedestals to retain the contrast. The development of the architectural mouldings of the base and pedestal therefore essentially depends on the degree of detail in the principal object. To treat a monument as a sham fountain from which no water flows is a coarse offense against external and internal truth of an art-work.

The ascending steps, which form the substructure of a monument, should recall the steps of stairs as little as possible, and they should therefore be so profiled, that the rain water may run off readily, and that their purpose may be apparent to the eye, Fig. 430. Inscriptions are best with rectangular cross section of letters; incisions of triangular section easily become illegible by exposure to weather. To arrange seats on the monument itself is improper, as it may easily be defaced. But it is proper to place seats in the vicinity of the monument, that it may be seen with ease.

1. In monuments whose principal subject consists of emblems or objects of any kind except statues, the base and pedestal should be arranged to harmonize therewith. A fine motive of such monuments is the Obelisk Fountain at Carlsruhe, Fig. 431; an obelisk is flanked by two griffins, lions, river-gods, etc, whose massive oblong pedestals project beyond the square of the obelisk; the latter being utilized as a running fountain, whose two basins may project beyond the pedestal at its sides. The same motive of plan may be used in monuments with statues.

2. Monuments with busts usually have a proportionally tall pedestal to receive the inscription; to prevent this from having too massive an effect, a special base may be inserted between the cap of the pedestal and the bust. The bust may stand free, may be placed against the real walls of porticoes, or may also be arranged as a memorial fountain. Busts may be protected from rain by a canopy-like structure.

3. Special care must be taken in detached monuments with statues that they have good proportions on all sides, and that they diminish properly upwards. It is then proper to cover

the figures with mantles, thus concealing the space between the legs, to place emblems at the feet of the figures, pedestals supporting an arm of the figure, and similar accessories, which give the chief object a broad base. Seated figures therefore often appear better than if standing, their lower portions being broader. In monuments with statues the pedestals usually look too broad when viewed diagonally, and the angles are therefore usually truncated, Fig. 4 [illegible]. In more richly detailed pedestals the angles are flanked by pilasters of slight projection, and an entablature is inserted between ther their capitals and the cap.

4. Monuments with two statues usually require an oblong pedestal, its wider side being in front. This frons then requires, not to seem to empty, to be broken up by reliefs, inscirbed tablets, and similar accessories. Figs. 433 and 434 represent the base of such a monument at Geneva.

5. Equestrian statues also need oblong pedestals, but their ends are turned in front. The bold mass of the body of the horse forms an esthetic contrast to the pedestal, at whose base angle statues may be placed.

6. One of the most commonly employed types of monuments is that with a central statue surrounded by four angle figures. An increased development in height occurs in such monuments, as well as a pyramidal enlargement downwards. It is preferable to make the pedestal lower also, placing the principal statue on a separate base, Fig. 435. Most seated angle statues also have separate bases.

Four subordinate statues are sometimes placed between the angle statues, or groups of emblems, coats of arms, and other symbolical or decorative accessories, which may be so arranged as to separate the lower part of the pedestal from the upper by a cap, and the base is independently developed, so that the upper part becomes a low frieze, flat or decorated by reliefs. The mass of the pedestal can thus be more richly treated, and its beauty of proportion be increased by these subdivisions.

7. The treatment and proportions of architectural backgrounds of monuments must be arranged in accordance with the monument, when they serve as a foil to heighten its importance. The architectural surroundings of a monument may be arranged and treated in the most varied ways; not too large a scale will always be preferable, that the monument may be as prominent as possible. Michael Angelo well understood how to make the statues themselves more imposing by the small scale of the architectural back-grounds.

There remains a word to be said in regard to monuments not detached or isolated. They are generally arranged as niche-
mon[illegible]

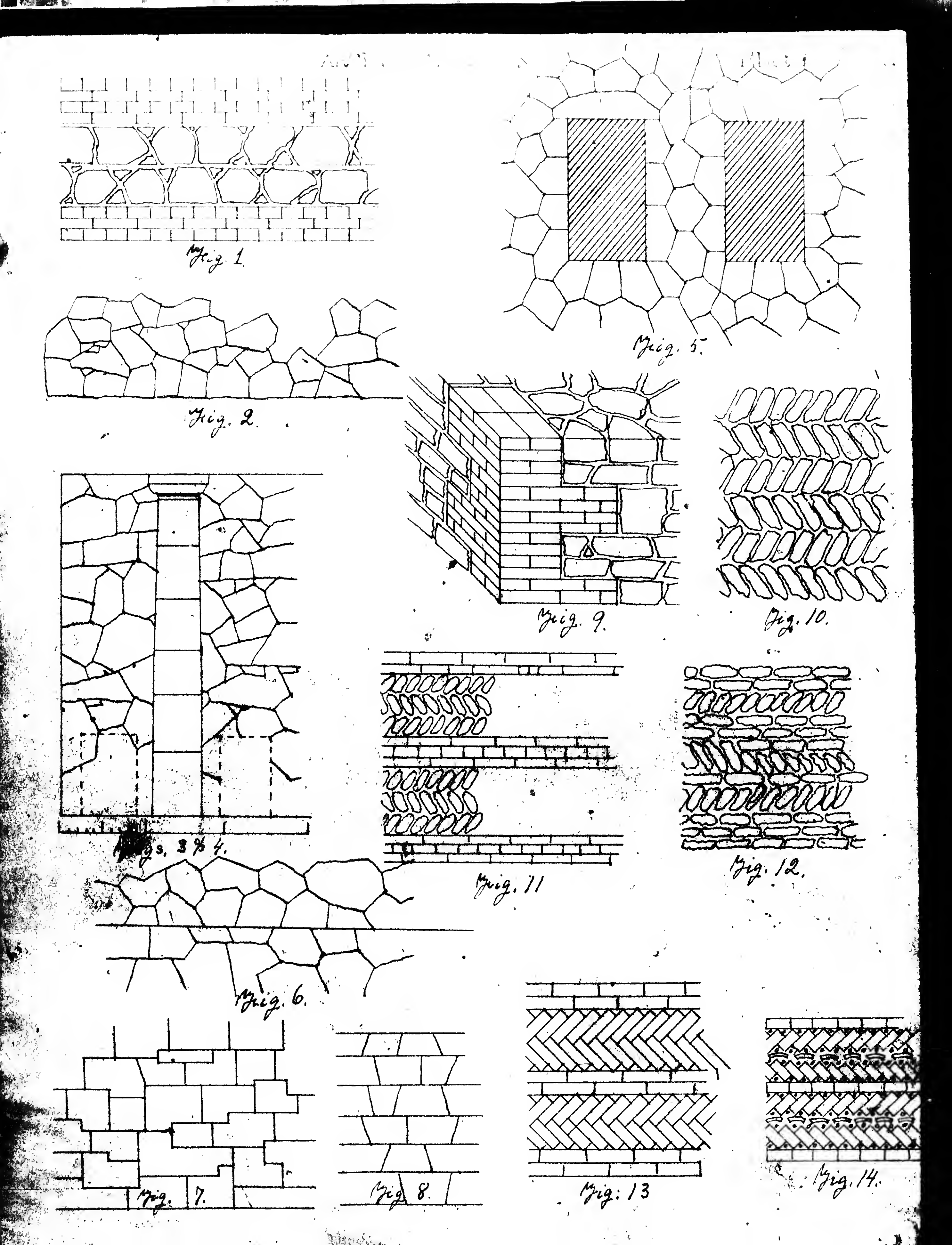
monuments attached to a wall, the architecture of the niche forming the principal motive of their architectural treatment. The motive of the triumphal arch was frequently used to good purpose in the more extensive designs of this kind. Four niches, each containing a statue, are also combined in a detached monument, that terminates at top in some form of roof. F. 436

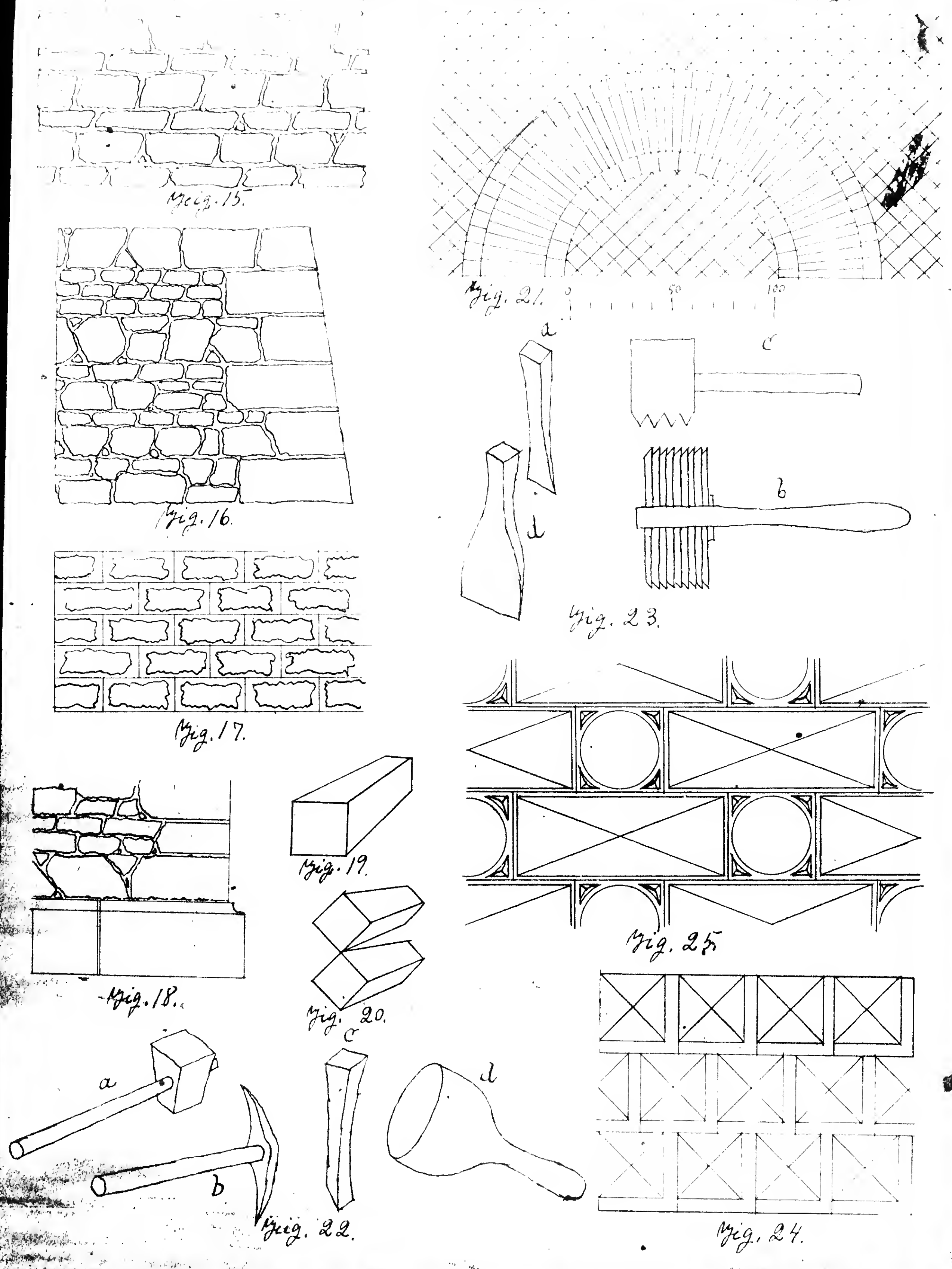
8. Purely architectural monuments are usually arranged in a few ground types as memorial columns, tower-like structures, temple-like buildings, and statues arranged about a central point. The memorial pillar of slender proportions may take the most varied forms; in larger designs, it is usually treated as a column with a capital, its abacus accessible by a winding staircase. Tower-like monuments are either solid, or arranged to serve as towers of observation.

These may also be treated in various ways, according to location. The substructure contains the entrance to the staircase (or an elevator, as in the towers of the Trocadero, Paris and sometimes forms an extended architectural design, sometimes takes the form of an open portico or that of a chapel, Fig 437 a, or that of a cross-shaped substructure b, its centre occupied by the winding staircase. In the arrangement a, the staircase may be placed in one of the apses and first connected with the central staircase above the vaults.

We have characteristic examples of temple-like and centrally arranged plans in the Walhalla and in the Ruhmeshalle. Such designs, with which are to be classed view pavilions, do not admit of a general discussion, but are entirely free compositions- the freest and most pleasant problems of the Architect, admitting of very numerous solutions.

(Note. Page 96 was omitted by mistake in numbering, so that this page should be 165).


Fig. 1
Fig. 2
Figs. 3 & 4.
Fig. 5.
Fig. 6.
Fig. 7.
Fig. 8.
Fig. 9.
Fig. 10.
Fig. 11
Fig. 12.
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Fig. 14.


Fig. 15.
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Fig. 25.

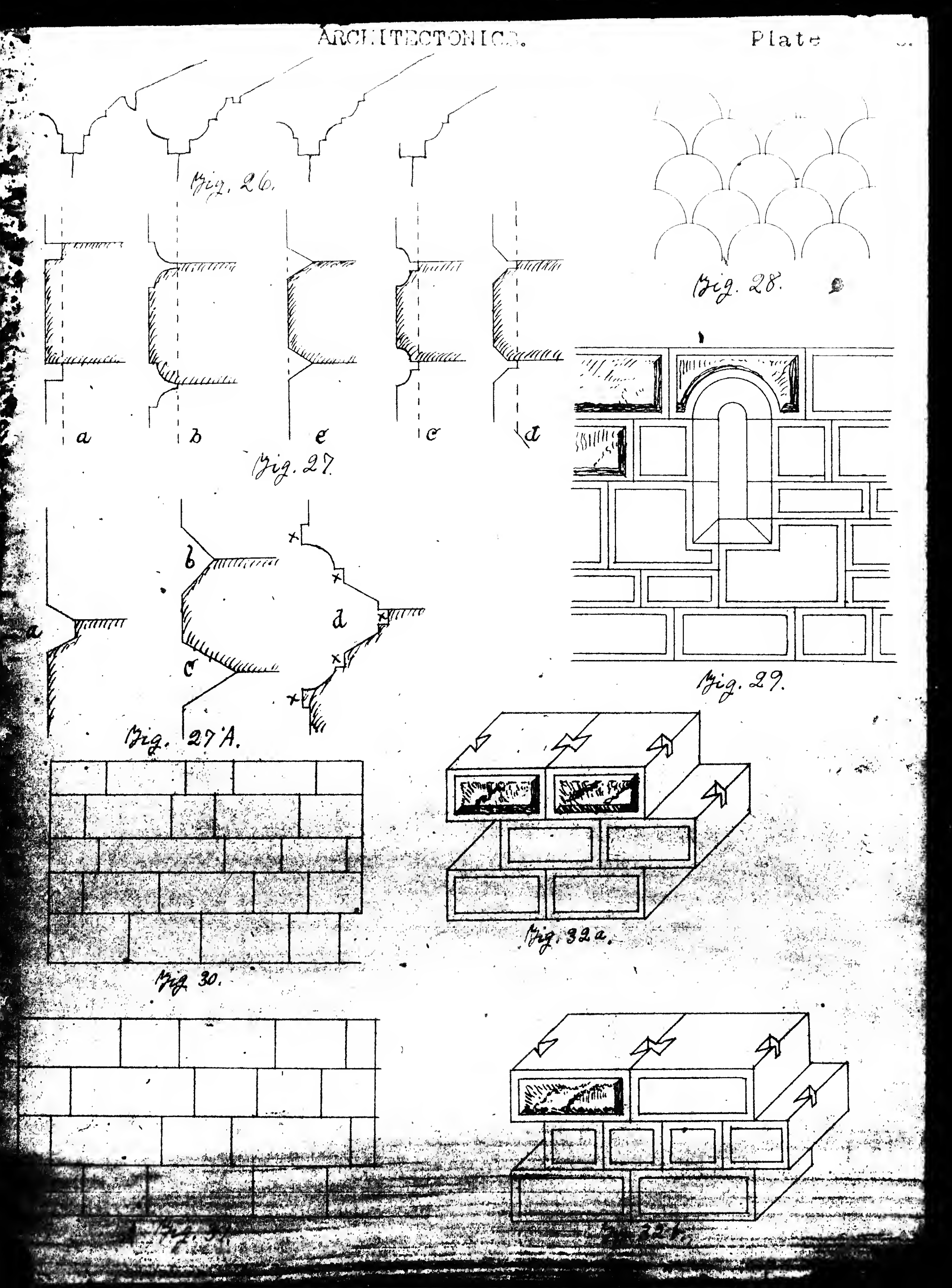


Fig. 26.

Fig. 27

Fig. 27 A.

Fig. 28.

Fig. 29.

Fig. 30.

Fig. 31.

Fig. 32 a.

Fig. 32 b.

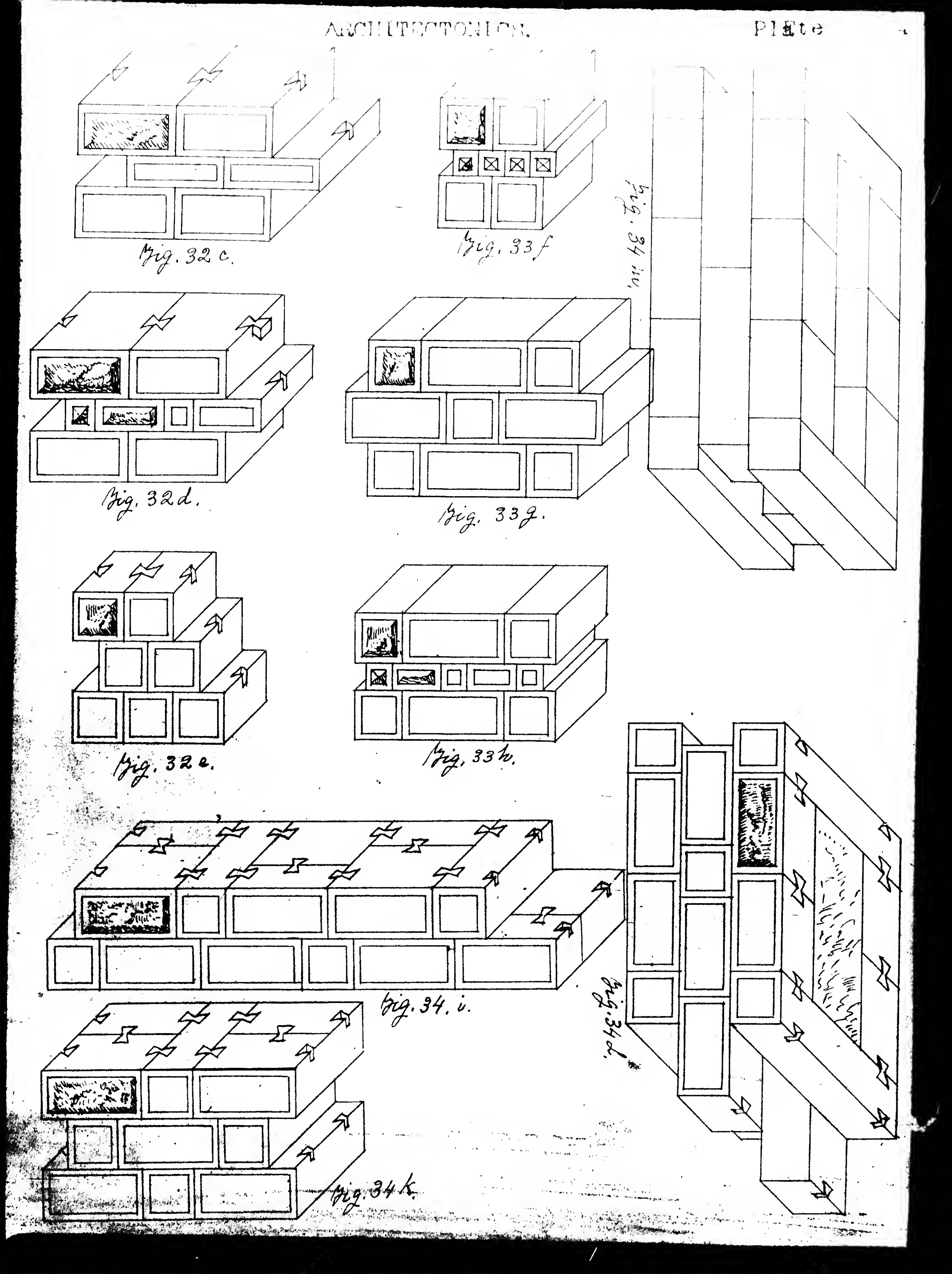
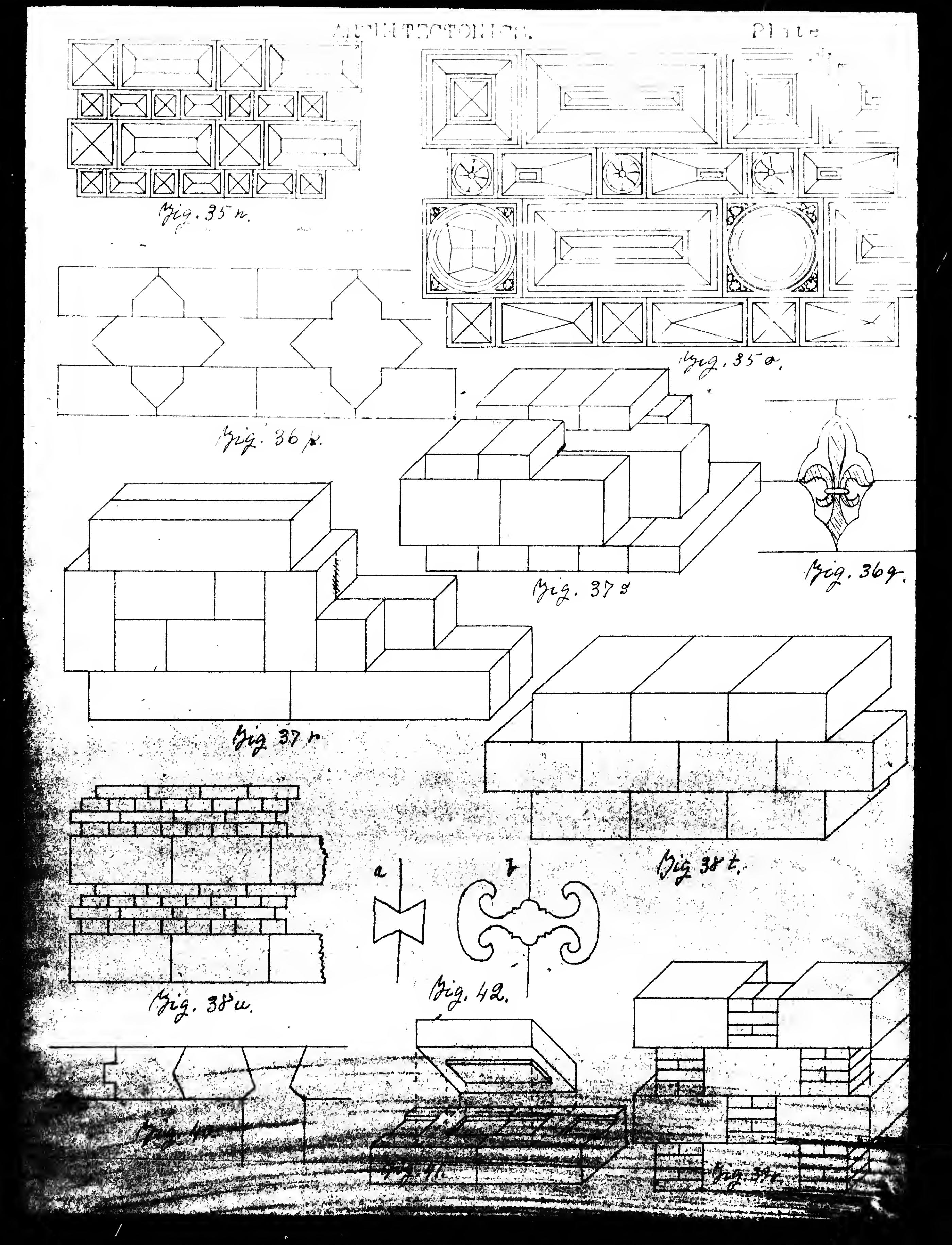


Fig. 32 c.
Fig. 33 f
Fig. 34 m.
Fig. 32 d.
Fig. 33 g.
Fig. 32 e.
Fig. 33 h.
Fig. 34. i.
Fig. 34 l.
Fig. 34 k.


Fig. 35 n.
Fig. 35 o.
Fig. 36 p.
Fig. 36 q.
Fig. 37 r
Fig. 37 s
Fig 38 t.
Fig. 38 u.
a
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Fig. 42.

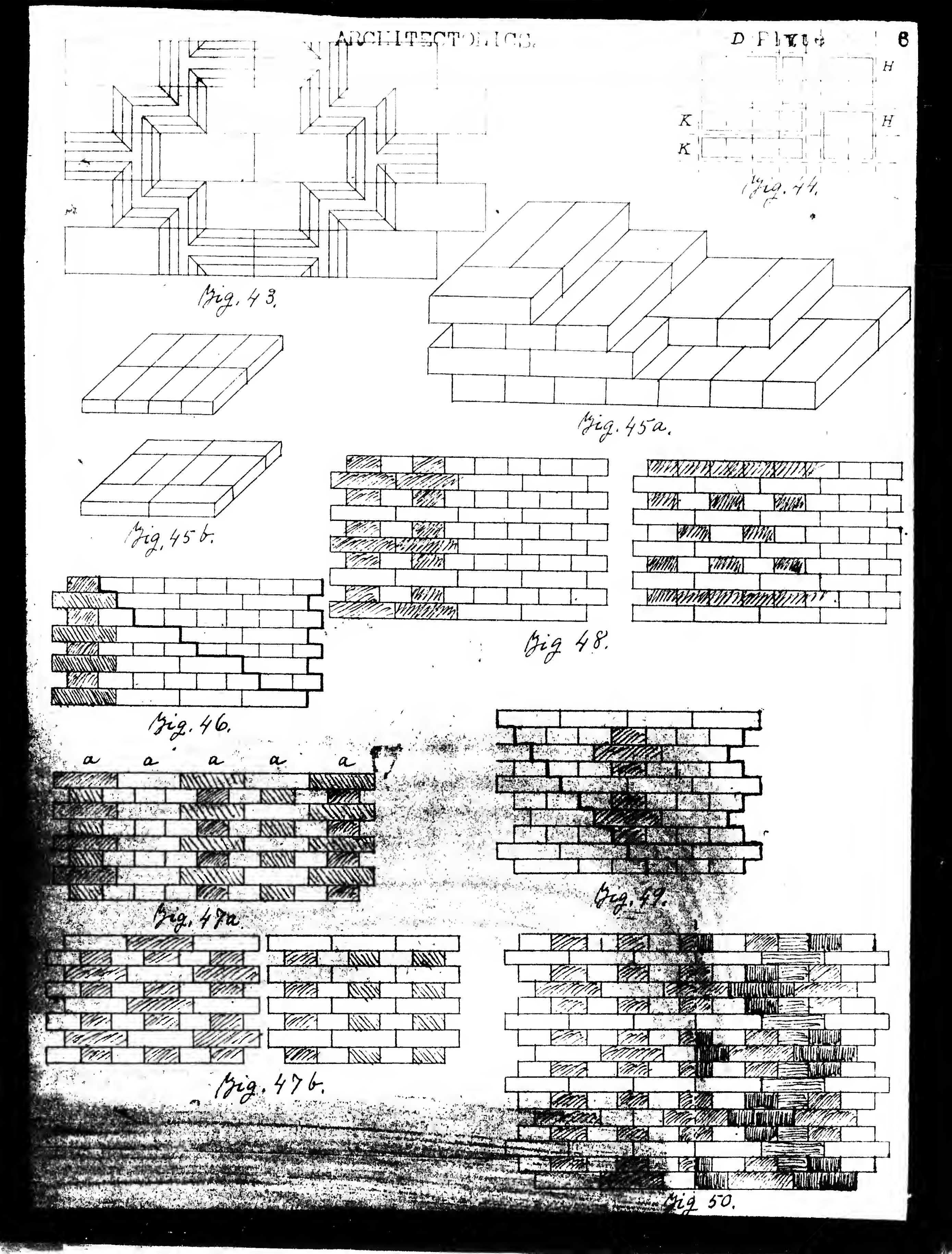


Fig. 43.

Fig. 44.

Fig. 45a.

Fig. 45b.

Fig. 46.

Fig. 47a.

Fig. 47b.

Fig. 48.

Fig. 49.

Fig. 50.

Fig. 51

Fig. 52.

Fig. 53.

Fig. 55.

Fig. 56.

Fig. 61.

Fig. 57.

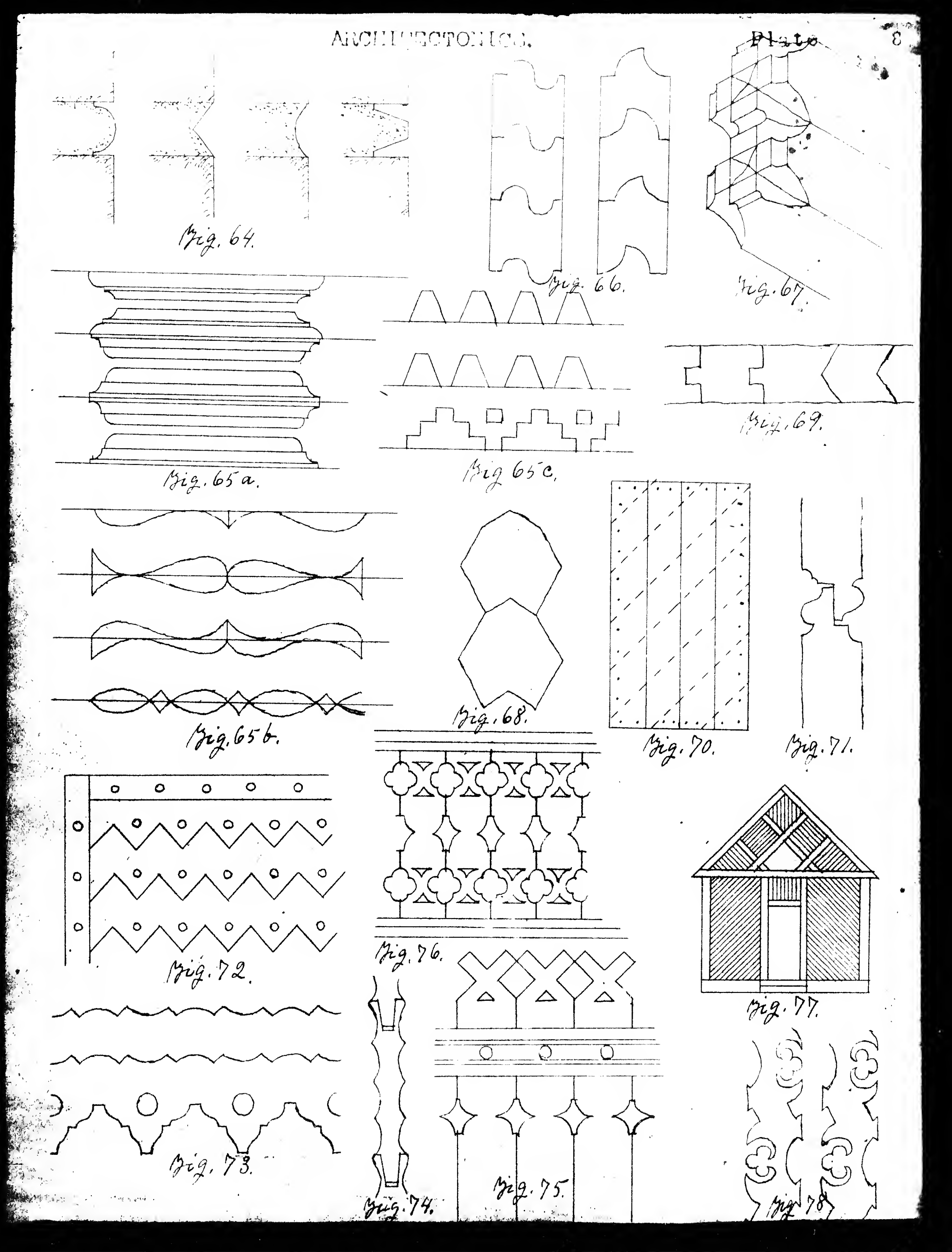
Fig. 58.

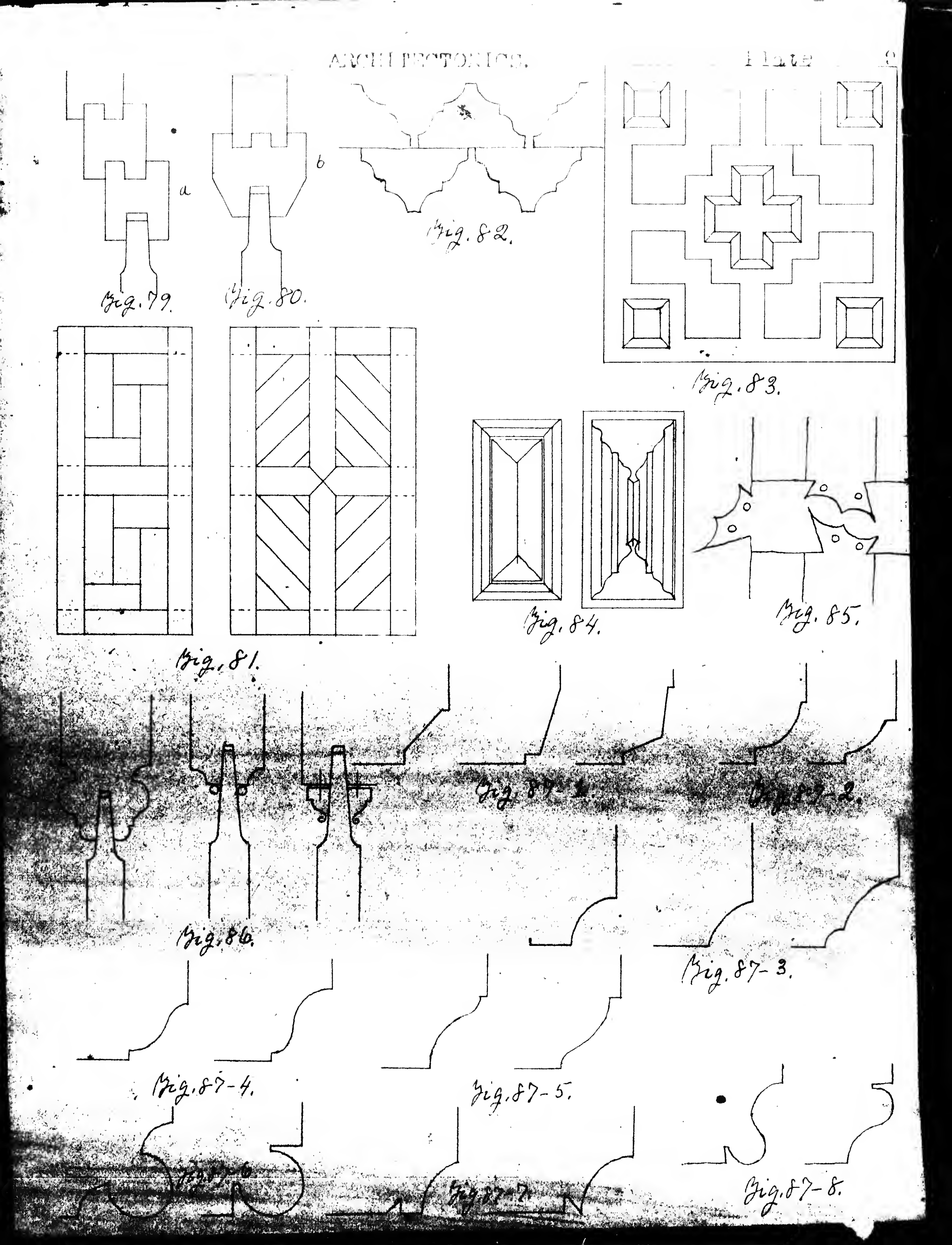
Fig. 59.

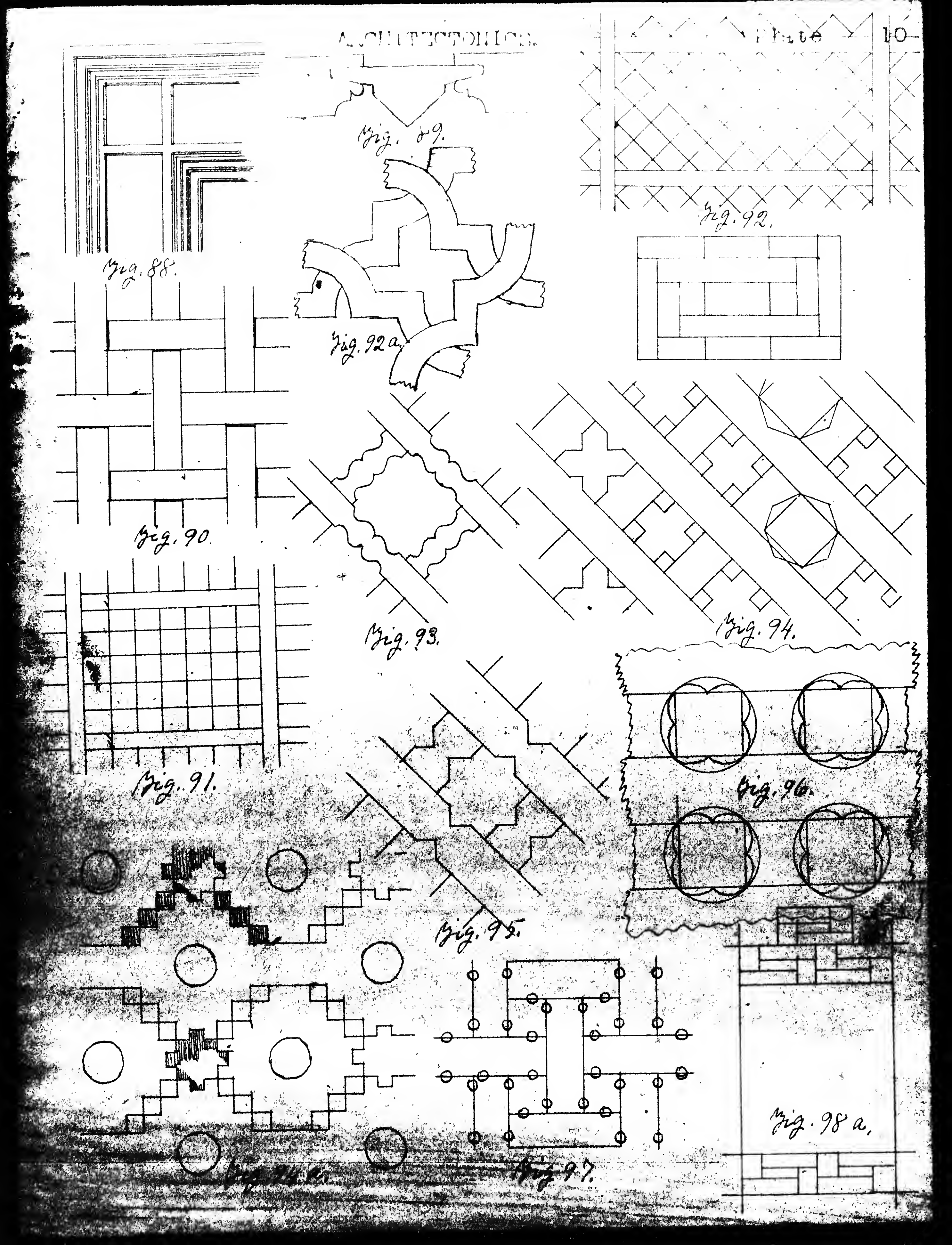
Fig. 60

Fig. 62.

Fig. 63.


Fig. 64.
Fig. 66.
Fig. 67.
Fig. 65 a.
Fig. 65 c.
Fig. 69.
Fig. 65 b.
Fig. 68.
Fig. 70.
Fig. 71.
Fig. 72.
Fig. 76.
Fig. 77.
Fig. 73.
Fig. 74.
Fig. 75.
Fig. 78.


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Fig. 79.
Fig. 80.
Fig. 81.
Fig. 82.
Fig. 83.
Fig. 84.
Fig. 85.
Fig. 86.
Fig. 87-1.
Fig. 87-2.
Fig. 87-3.
Fig. 87-4.
Fig. 87-5.
Fig. 87-6
Fig. 87-7.
Fig. 87-8.


Fig. 88.
Fig. 89.
Fig. 92.
Fig. 92 a.
Fig. 90.
Fig. 91.
Fig. 93.
Fig. 94.
Fig. 95.
Fig. 96.
Fig. 94 a.
Fig. 97.
Fig. 98 a.

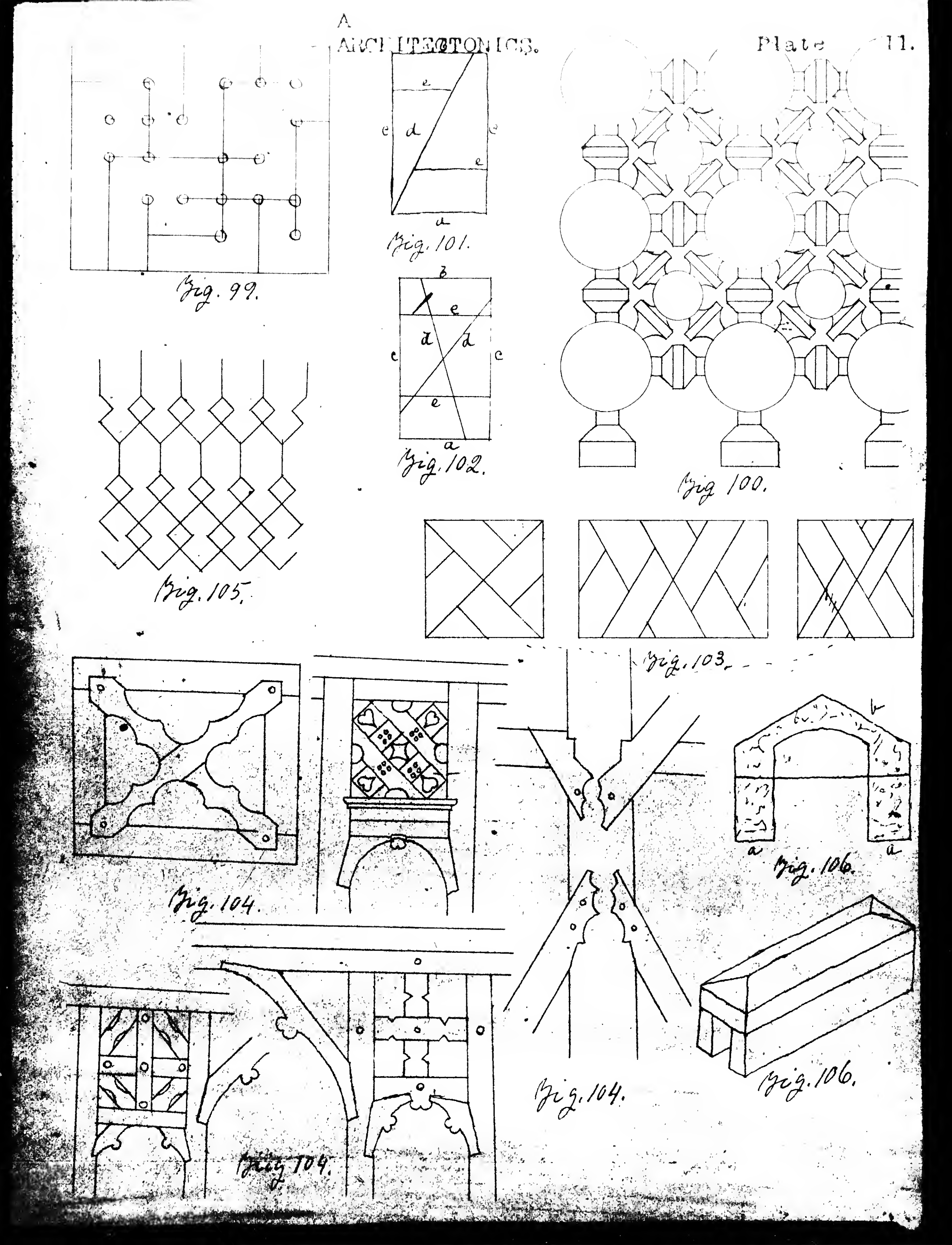


Fig. 99.

Fig. 101.

Fig. 102.

Fig. 100.

Fig. 105.

Fig. 103.

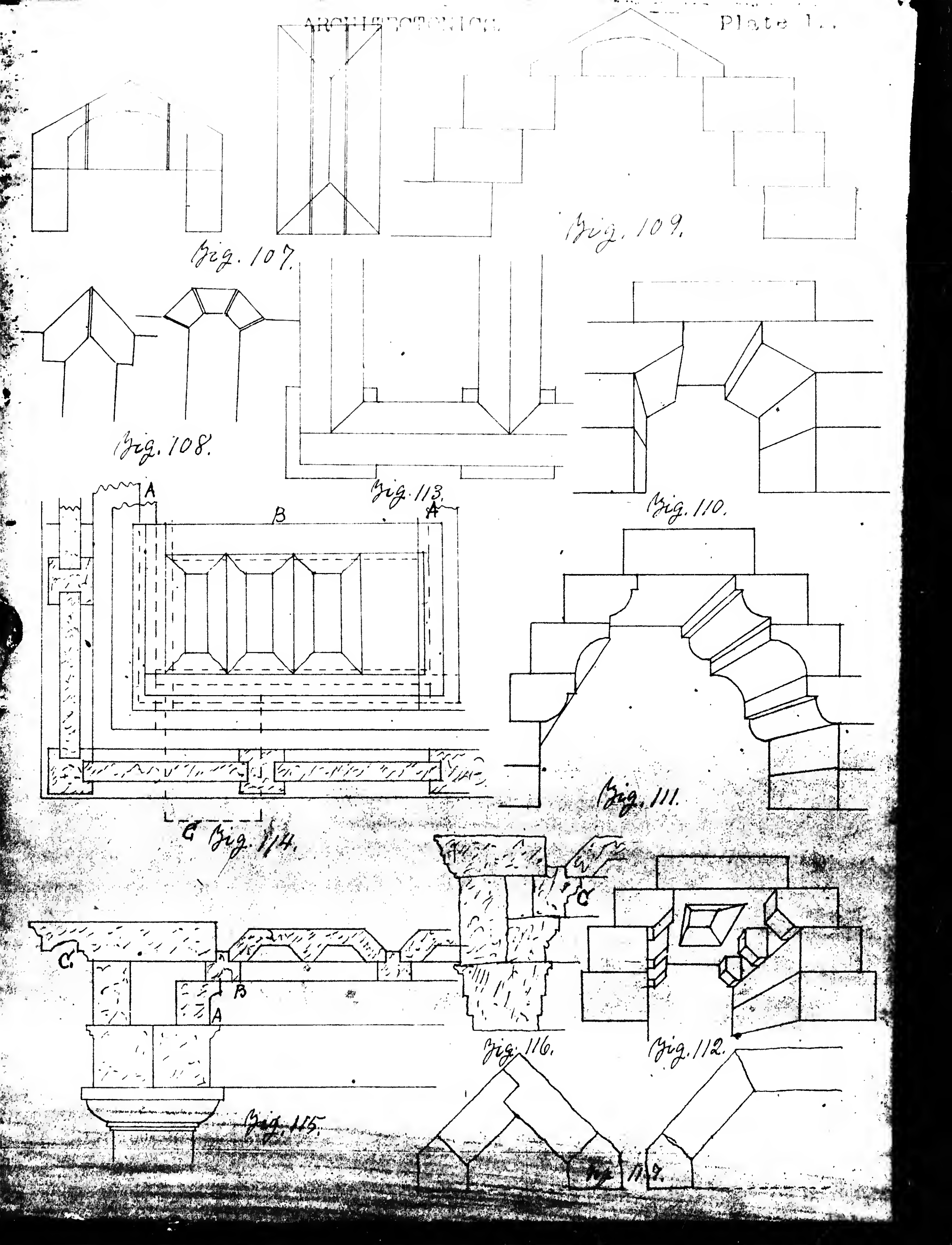
Fig. 104.

Fig. 106.

Fig. 104.

Fig. 106.

Fig. 104.


Fig. 107.
Fig. 109.
Fig. 108.
Fig. 113.
Fig. 110.
A
B
A
C
Fig. 114.
Fig. 111.
C
C
B
A
Fig. 116.
Fig. 112.
Fig. 115.
Fig. 117.

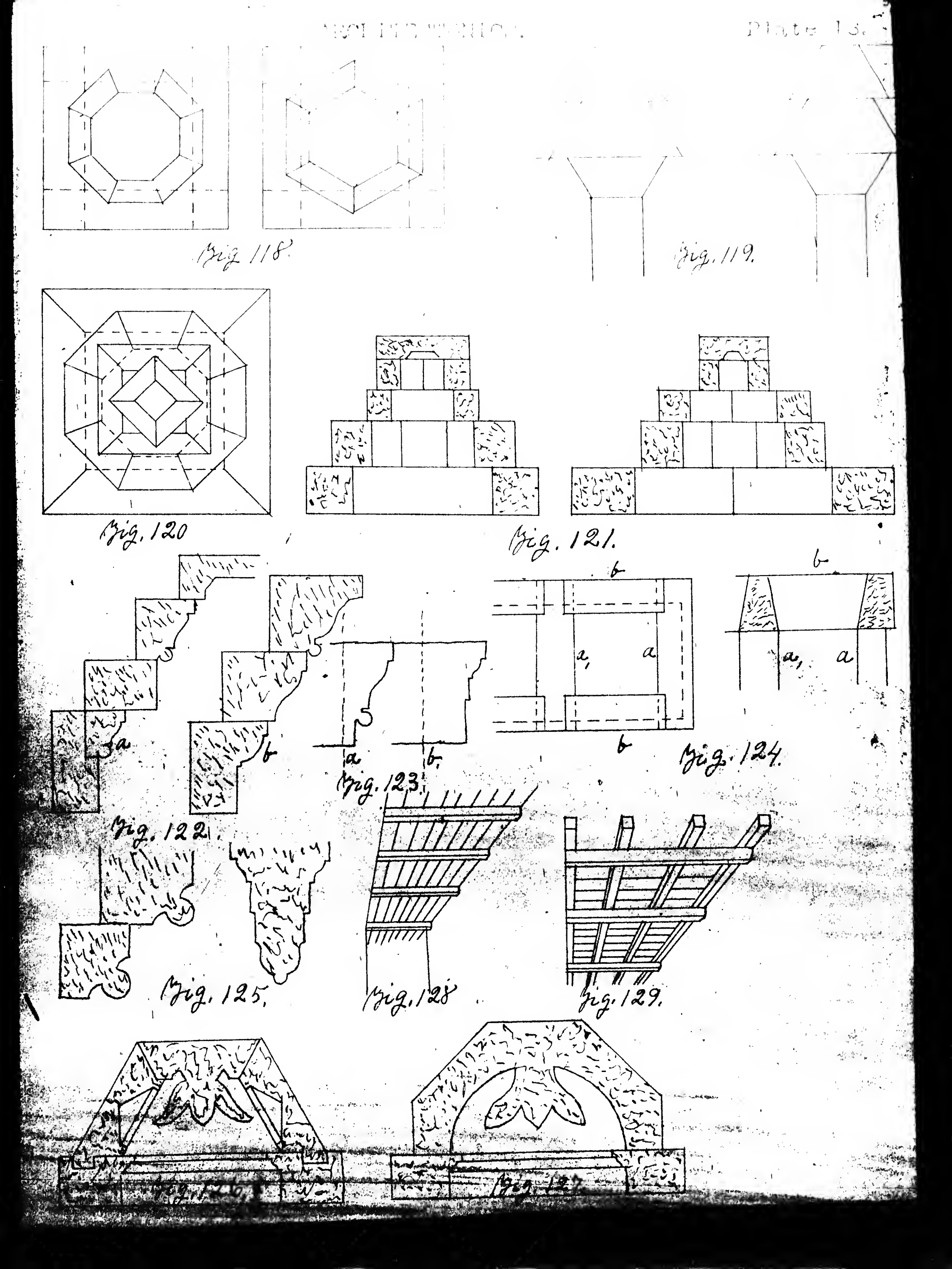


Fig 118.
Fig. 119.
Fig. 120
Fig. 121.
Fig. 122.
Fig. 123.
Fig. 124.
Fig. 125.
Fig. 128.
Fig. 129.
Fig. 126.
Fig. 127.

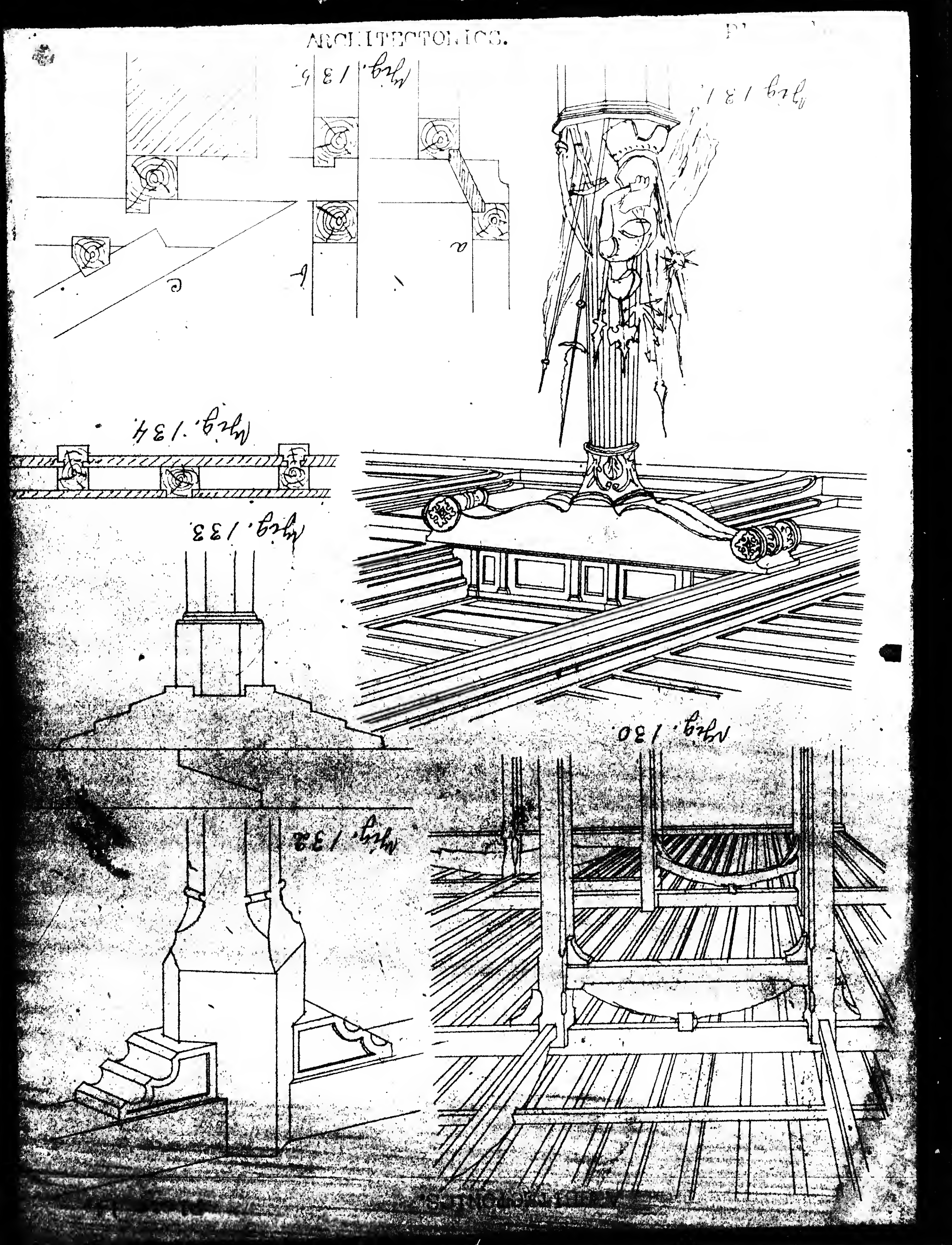
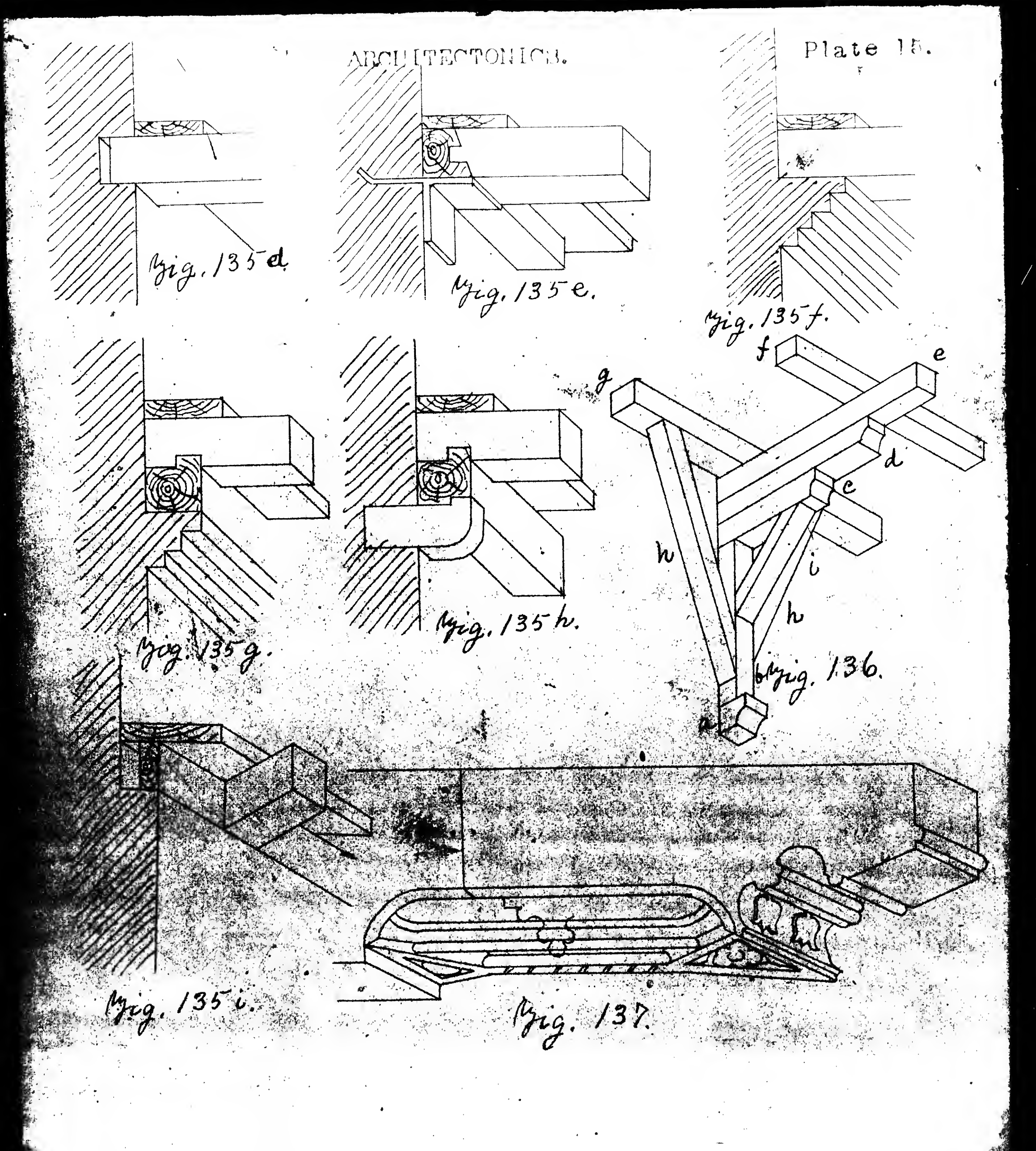
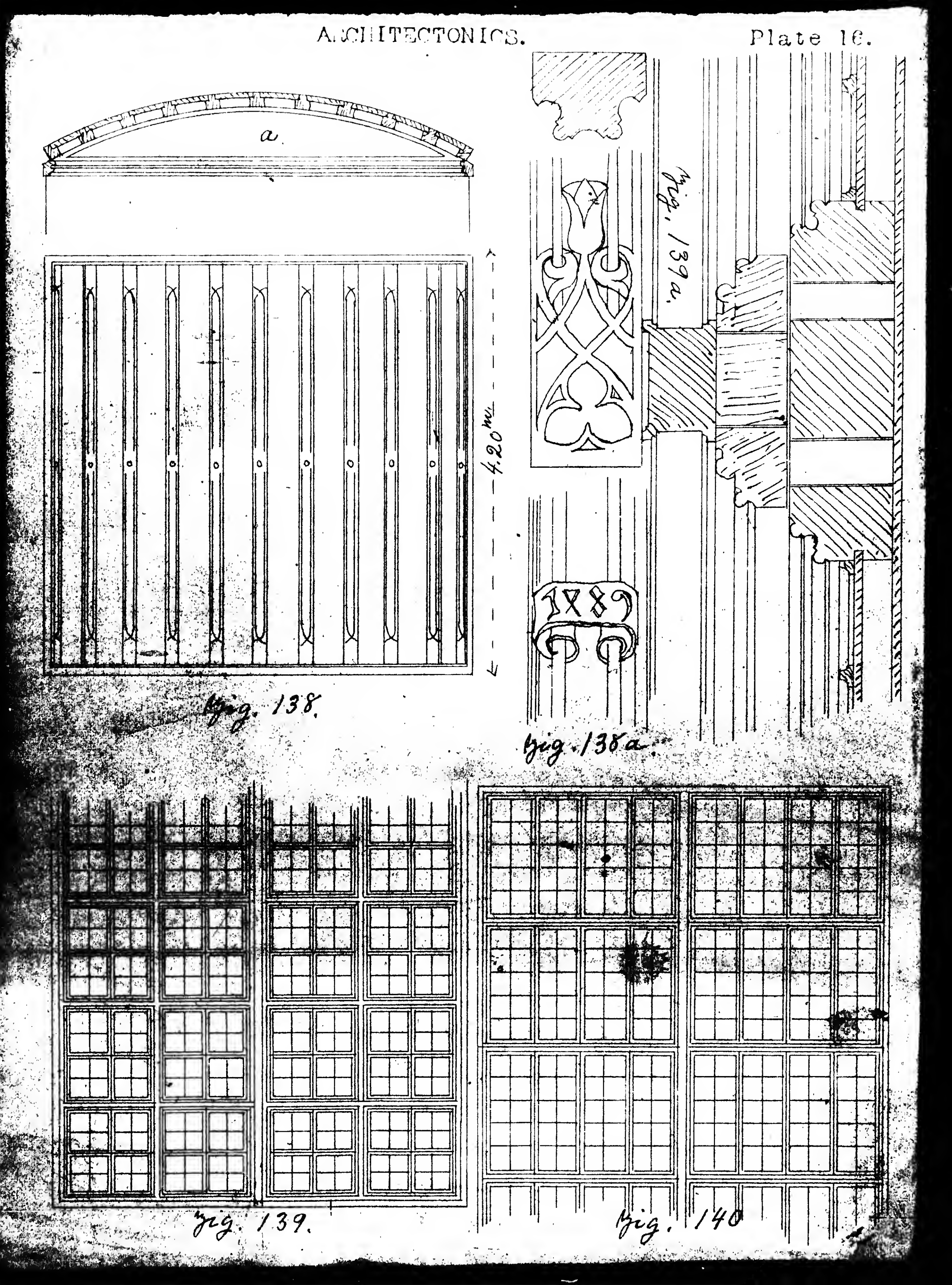


Fig. 135
a
b
c
Fig. 131
Fig. 134
Fig. 133
Fig. 132
Fig. 130


Fig. 135 d.
Fig. 135 e.
Fig. 135 f.
f
e
g
d
c
h
i
h
Fig. 135 g.
Fig. 135 h.
Fig. 136.
Fig. 135 i.
Fig. 137.


a.
4.20 m.
Fig. 139 a.
1789
Fig. 138.
Fig. 138 a.
Fig. 139.
Fig. 140

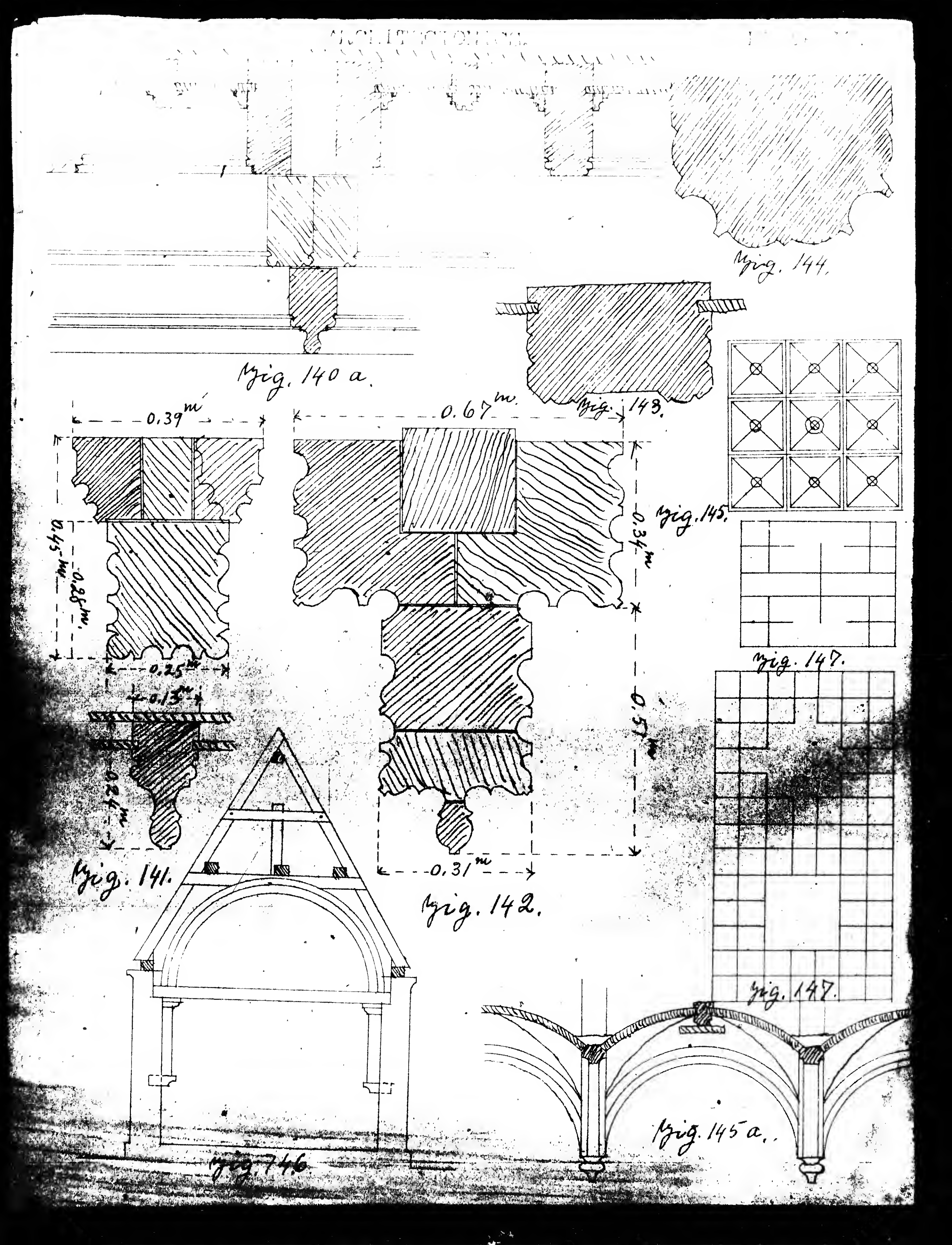
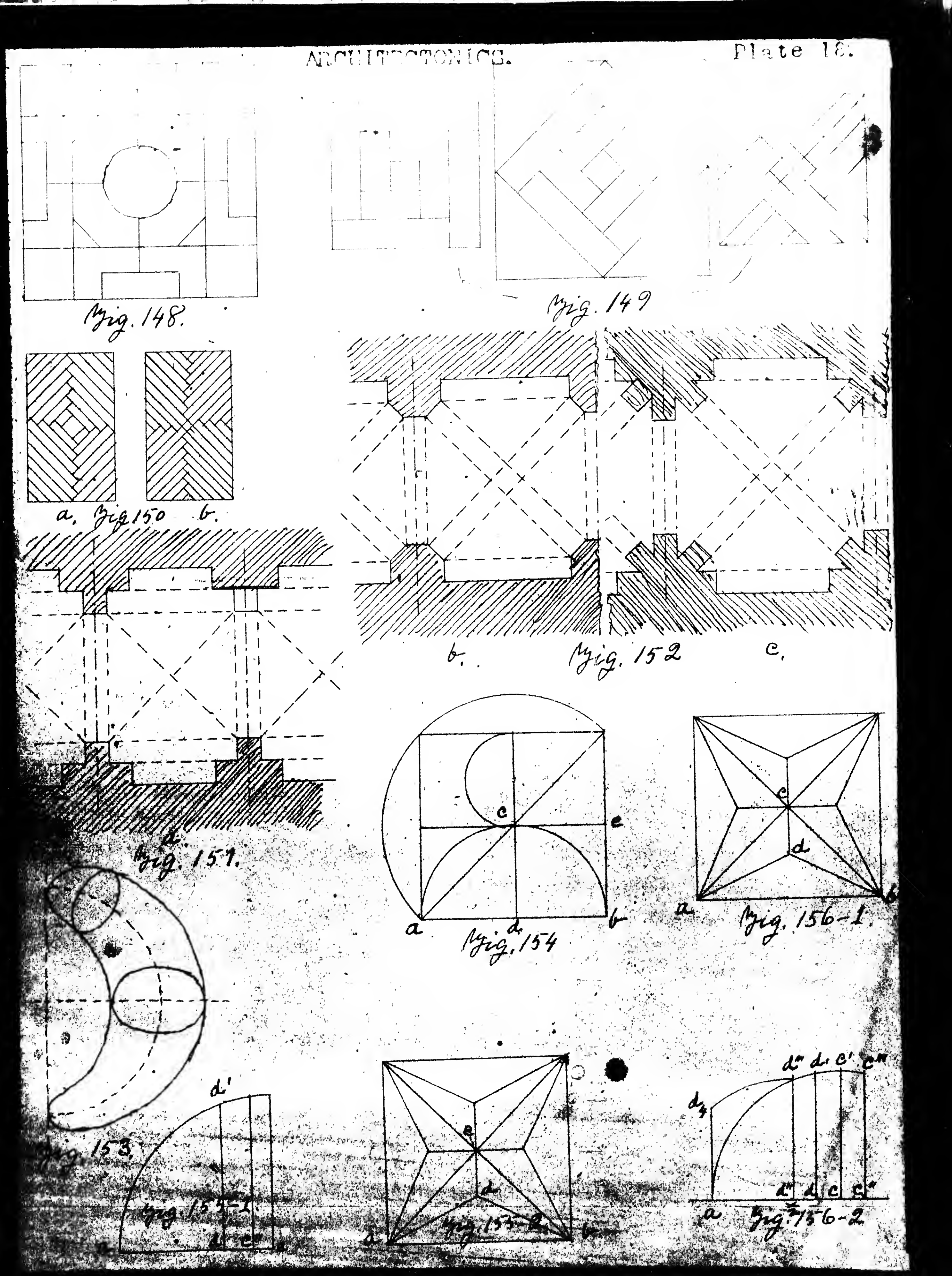
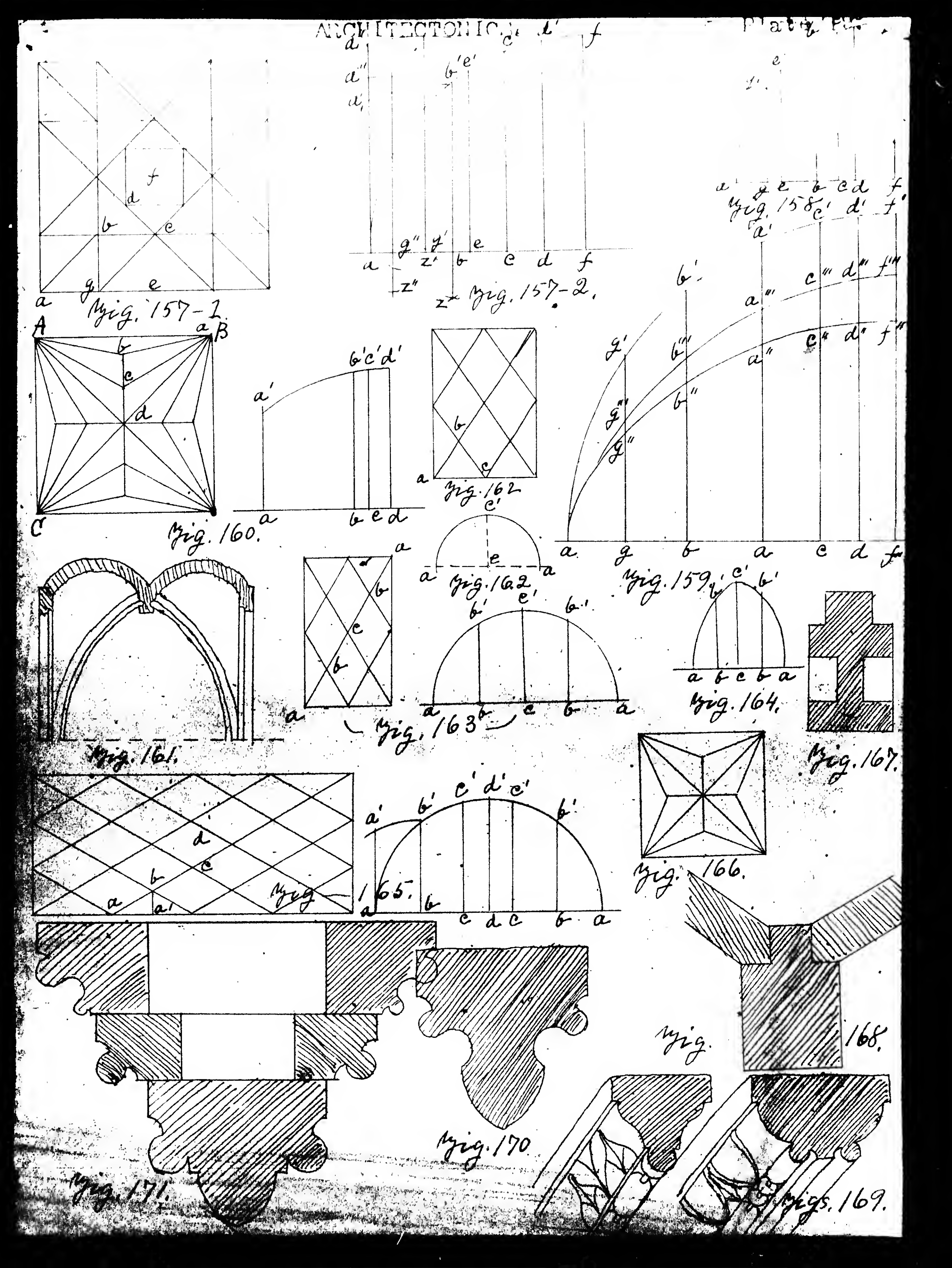


Fig. 140 a.
Fig. 144.
Fig. 143.
0.39 m
0.67 m
0.45 m
0.28 m
0.25 m
0.15 m
0.24 m
0.34 m
0.57 m
0.31 m
Fig. 145.
Fig. 147.
Fig. 141.
Fig. 142.
Fig. 146.
Fig. 145 a.


Fig. 148.
Fig. 149
a. Fig 150 b.
b. Fig. 152 c.
d
Fig. 151.
c
e
a
d
b
Fig. 154
c
d
a
b
Fig. 156-1.
Fig. 153.
d'
Fig. 155-1.
d c
e
d
a
b
Fig. 155-2.
d'' d c' c''
d
d'' d c c''
a
Fig. 156-2


Fig. 157-1.
Fig. 157-2.
Fig. 158.
Fig. 159.
Fig. 160.
Fig. 161.
Fig. 162
Fig. 162.
Fig. 163.
Fig. 164.
Fig. 165.
Fig. 166.
Fig. 167.
Fig. 168.
Figs. 169.
Fig. 170
Fig. 171.

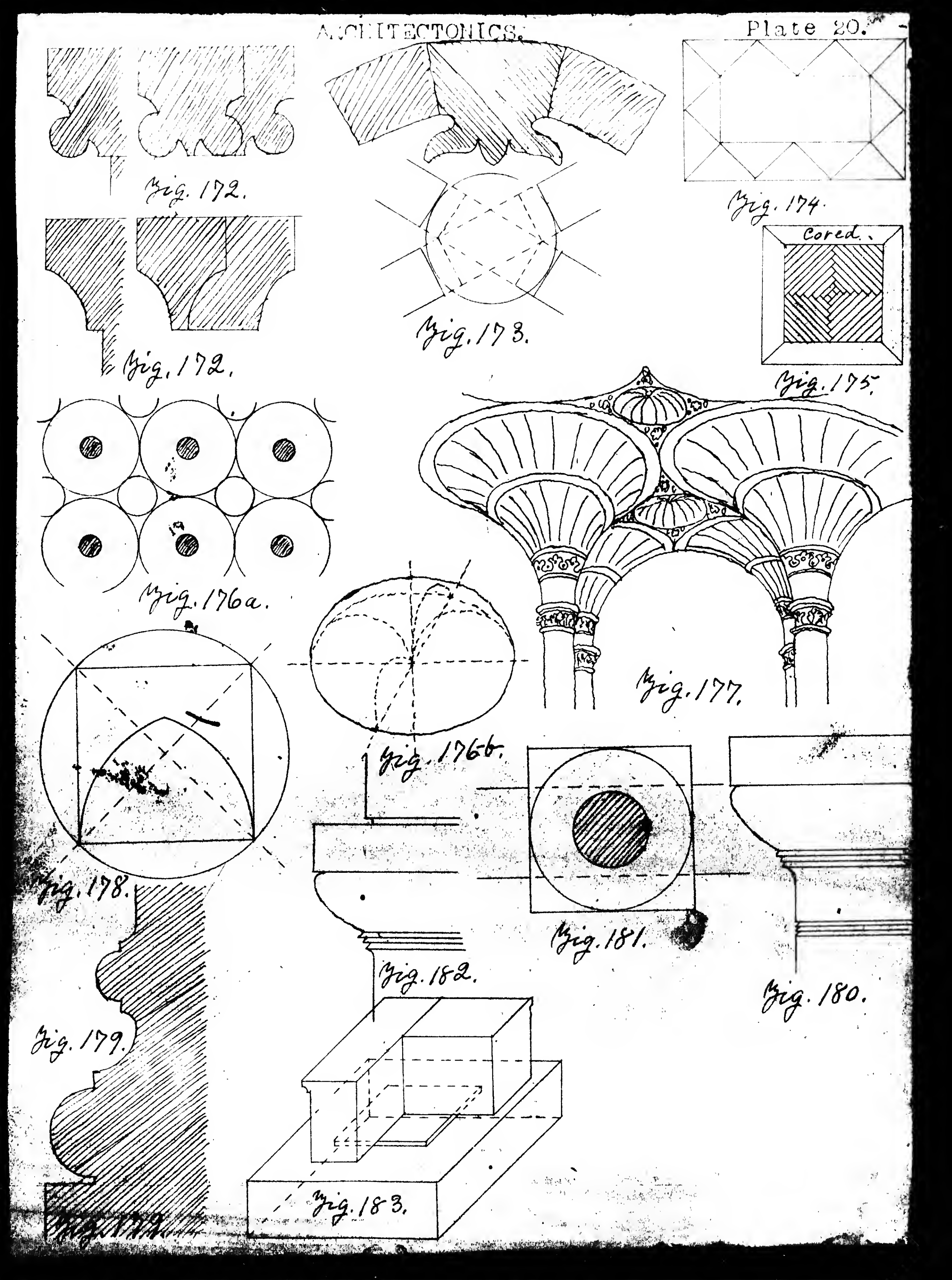
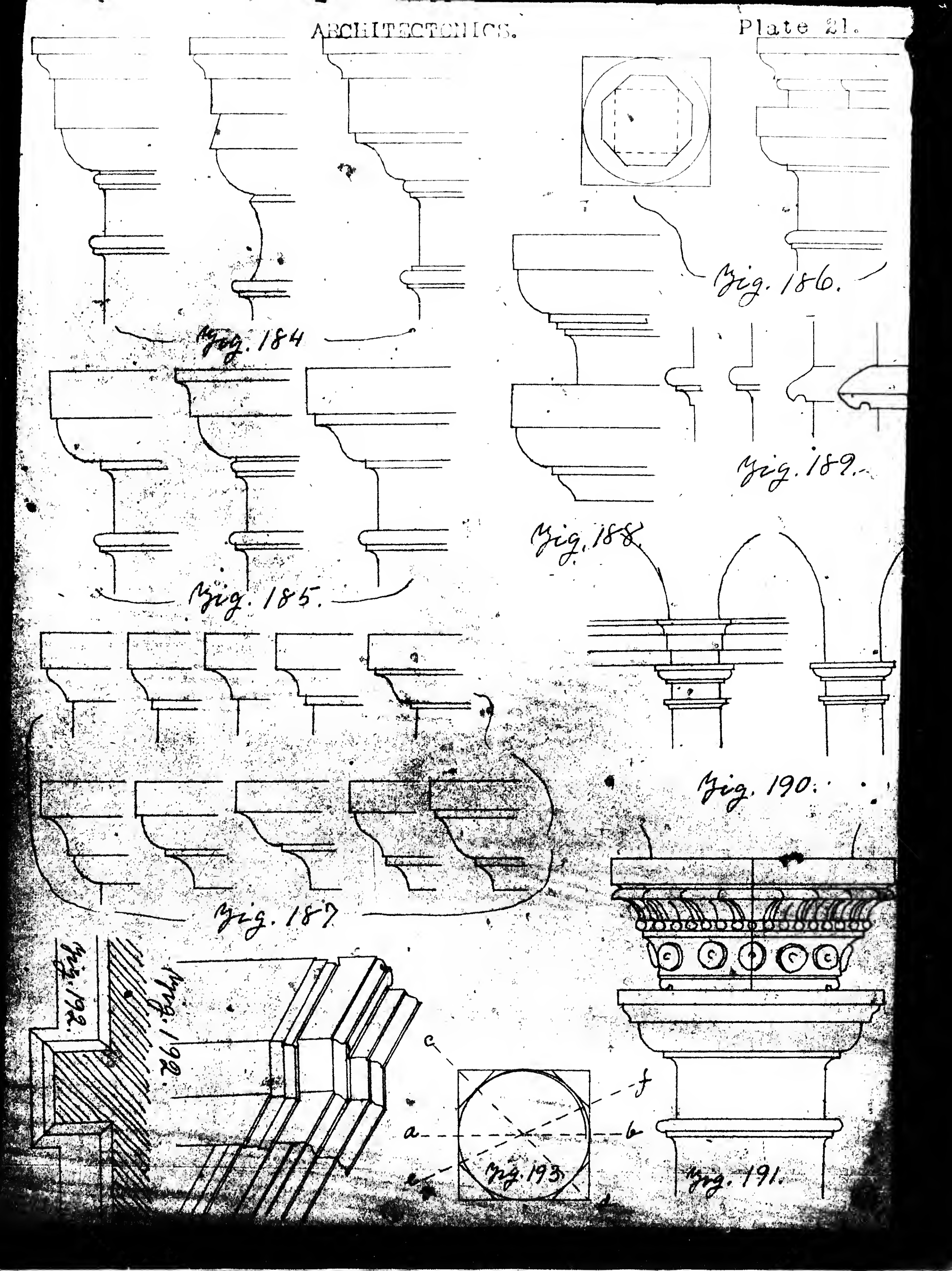
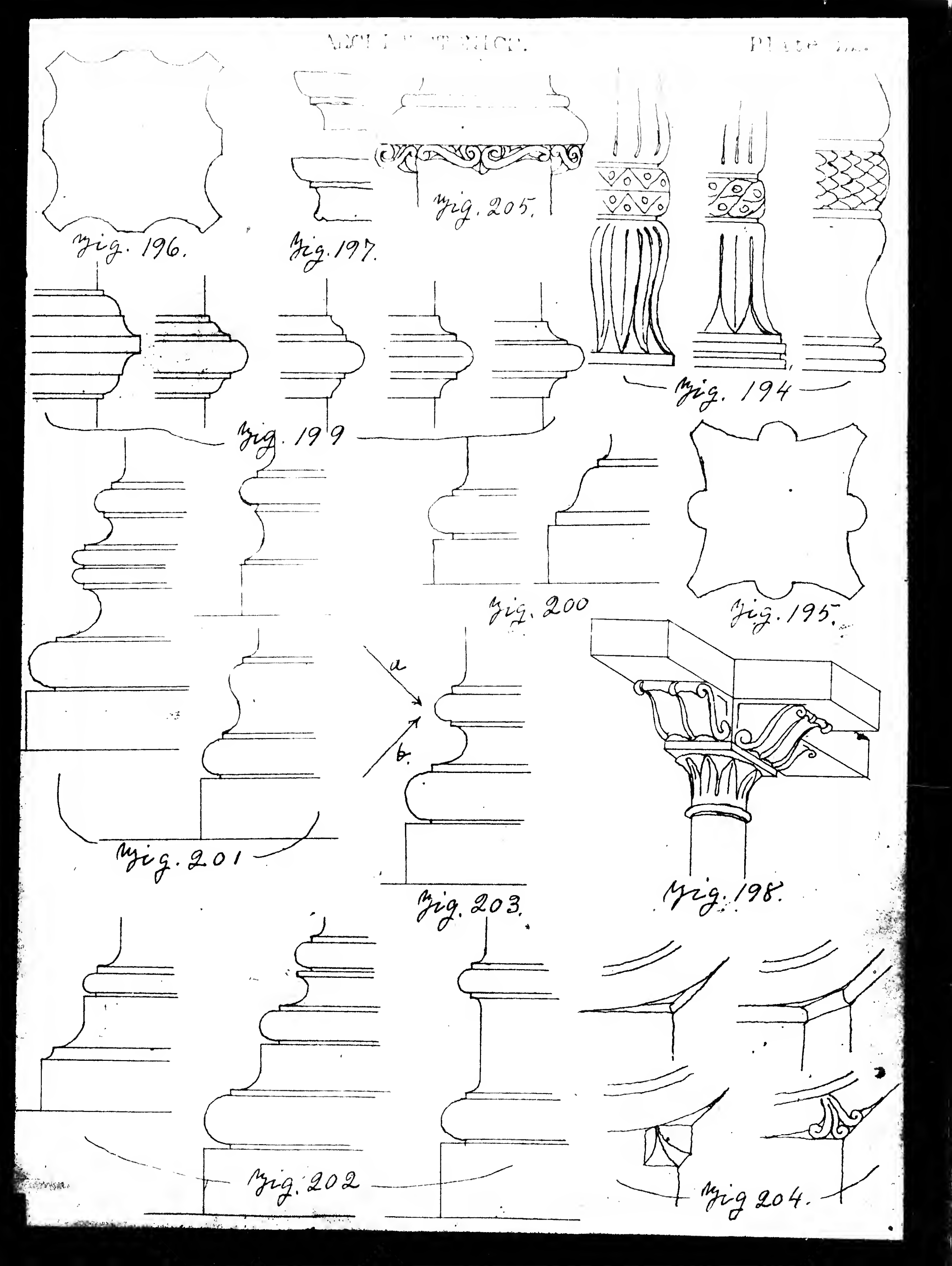
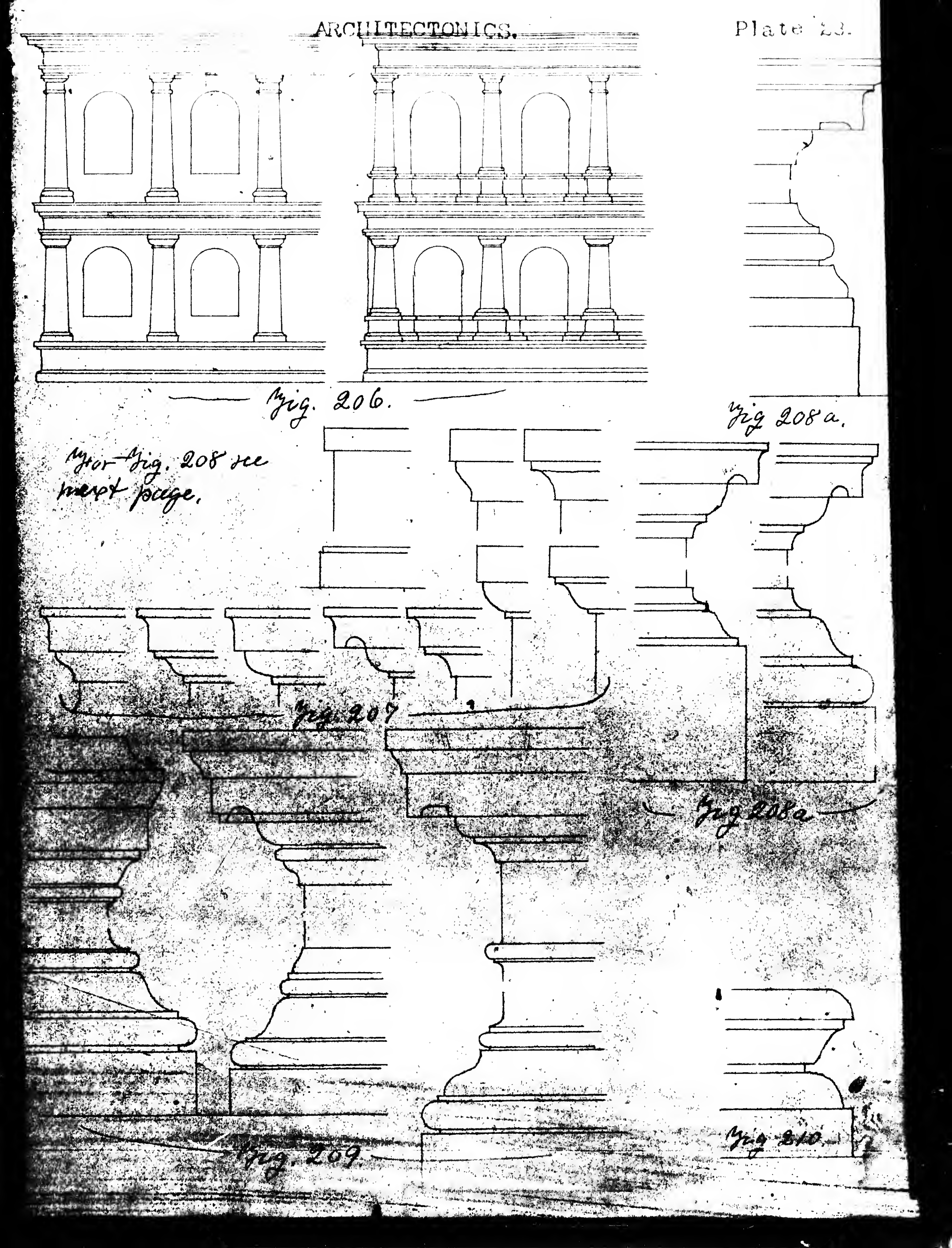


Fig. 172.
Fig. 172.
Fig. 173.
Fig. 174.
Fig. 175.
Fig. 176a.
Fig. 176b.
Fig. 177.
Fig. 178.
Fig. 179.
Fig. 180.
Fig. 181.
Fig. 182.
Fig. 183.
Fig. 179.


Fig. 184
Fig. 185.
Fig. 186.
Fig. 187
Fig. 188.
Fig. 189.
Fig. 190.
Fig. 191.
Fig. 192.
Fig. 192.
Fig. 193.
c
f
a
b
e


Fig. 196.
Fig. 197.
Fig. 205.
Fig. 194
Fig. 199
Fig. 200
Fig. 195.
a
b.
Fig. 201
Fig. 203.
Fig. 198.
Fig. 202
Fig. 204.


Fig. 206.
Fig 208 a.
For Fig. 208 see next page.
Fig. 207
Fig 208a
Fig. 209
Fig. 210.

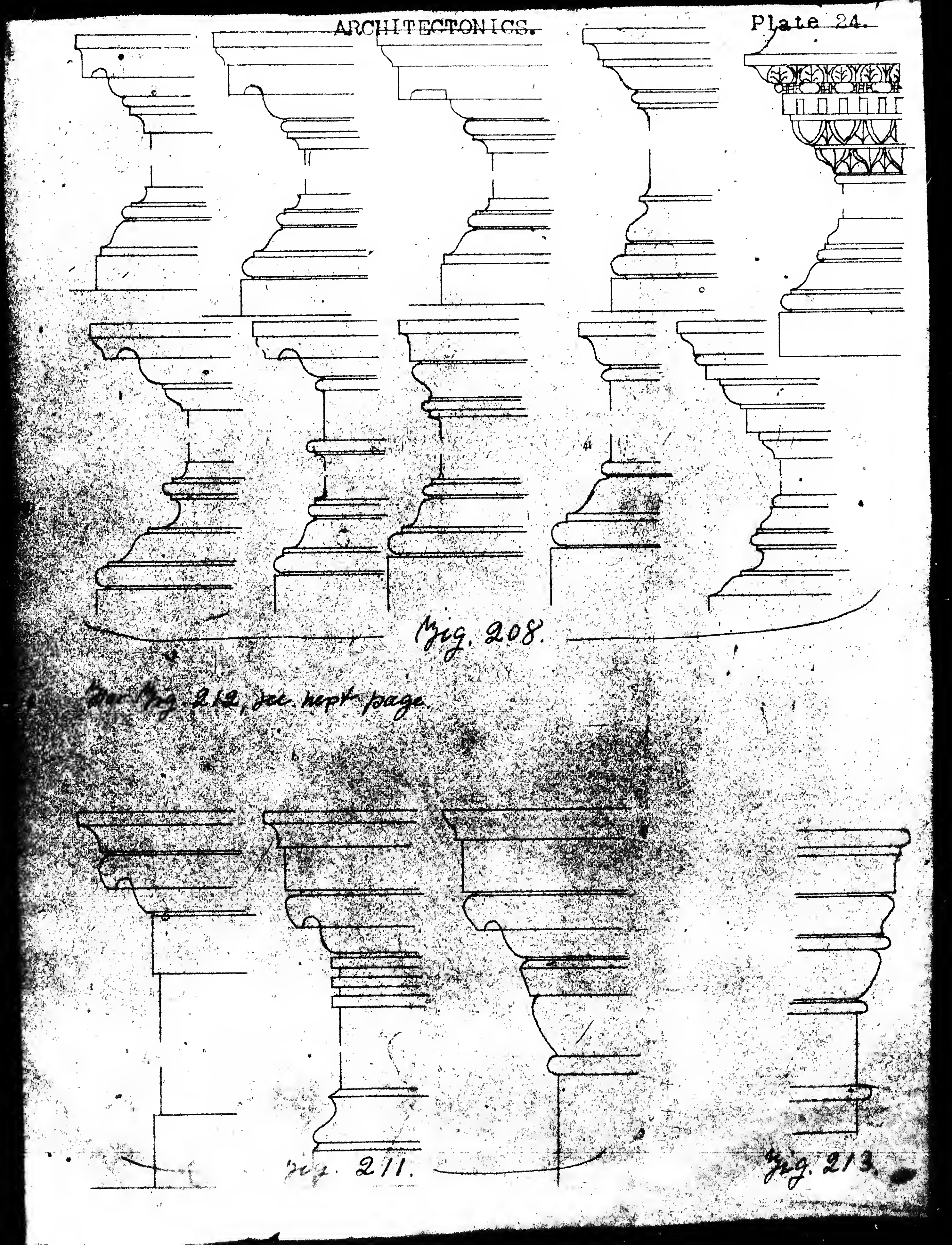
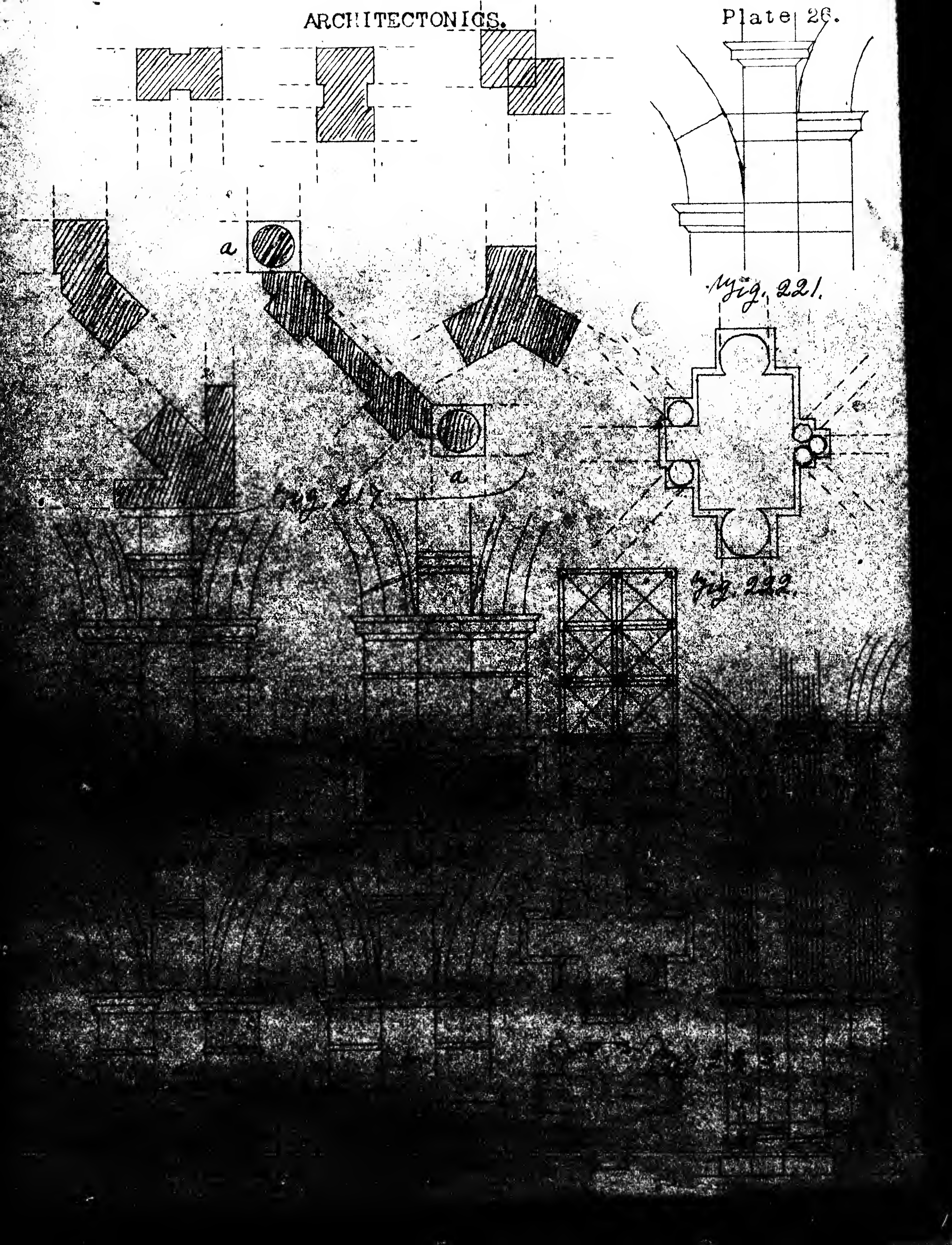
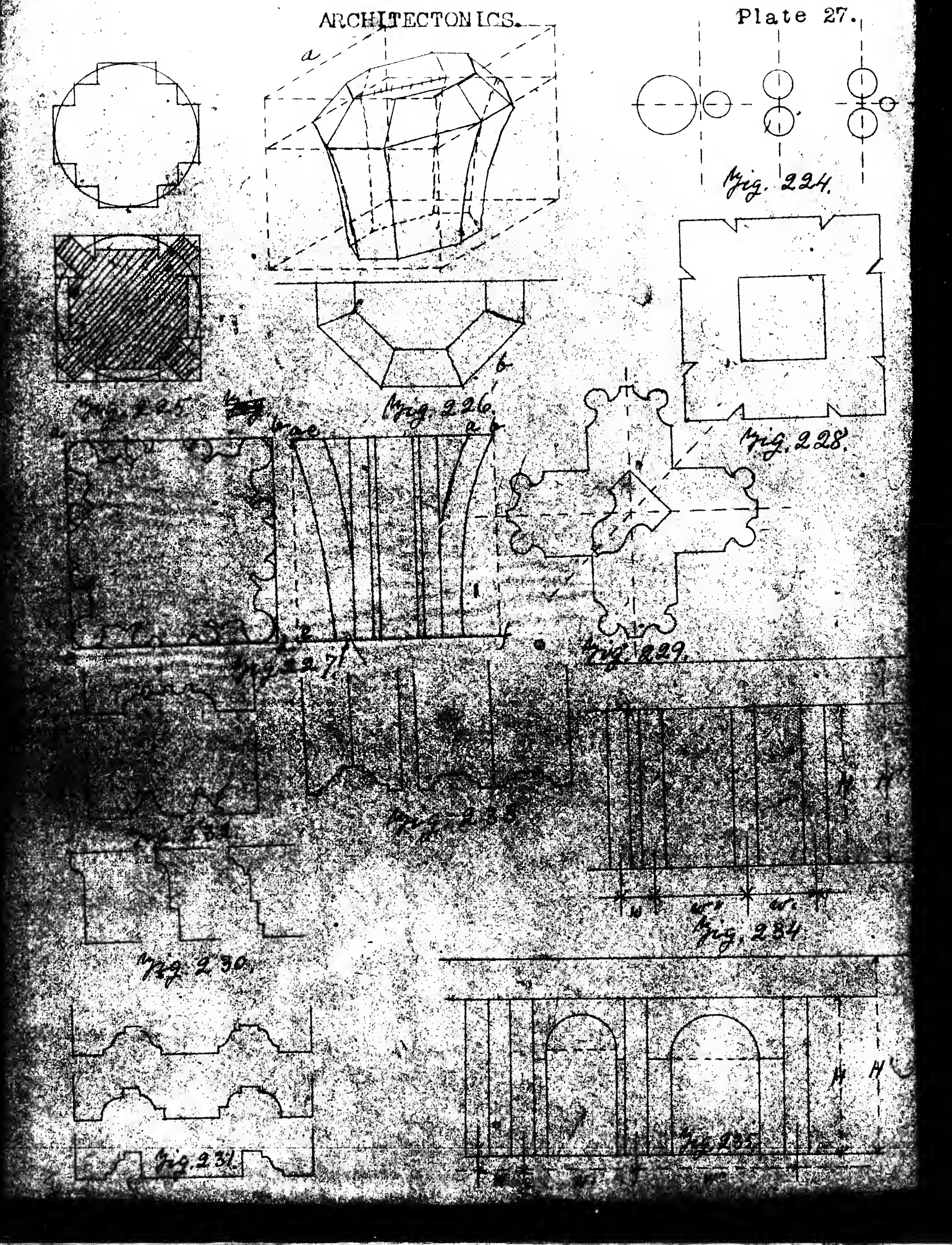

Fig. 208.
For Fig 212, see next page
Fig. 211.
Fig. 213.

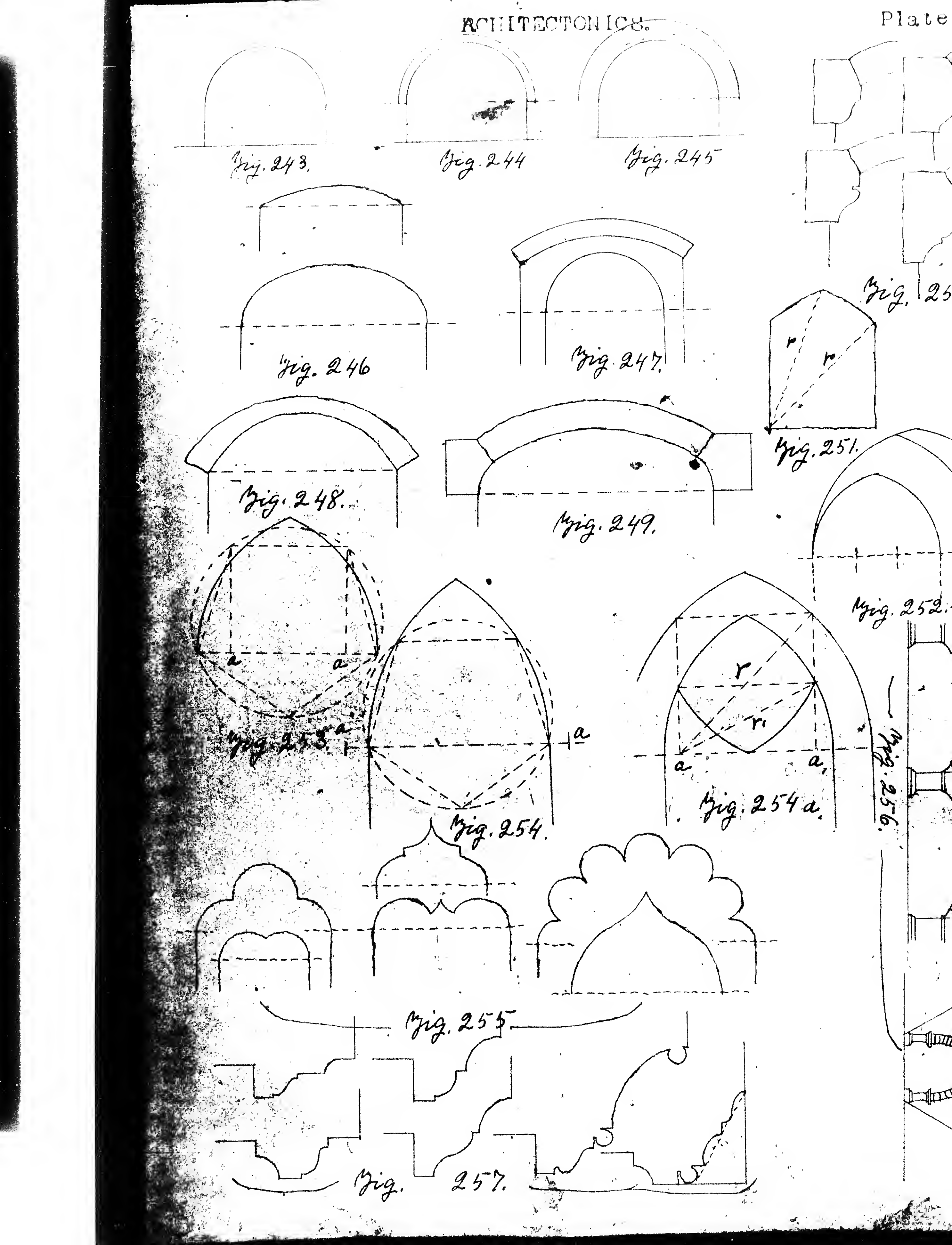
Fig. 212.

Fig. 215.




a
a
Fig. 221.
Fig. 222.


a
b
Fig. 224.
Fig. 225
Fig. 226.
Fig. 227.
Fig. 228.
Fig. 229.
Fig. 230.
Fig. 231.
Fig. 233.
Fig. 234.
Fig. 235.
H
H


Fig. 243.
Fig. 244
Fig. 245
Fig. 246
Fig. 247.
Fig. 248.
Fig. 249.
Fig. 251.
Fig. 252.
Fig. 253.
Fig. 254.
Fig. 254 a.
Fig. 255.
Fig. 256.
Fig. 257.
r
r
a
a
a
a
r
r,
a
a,
Fig. 25

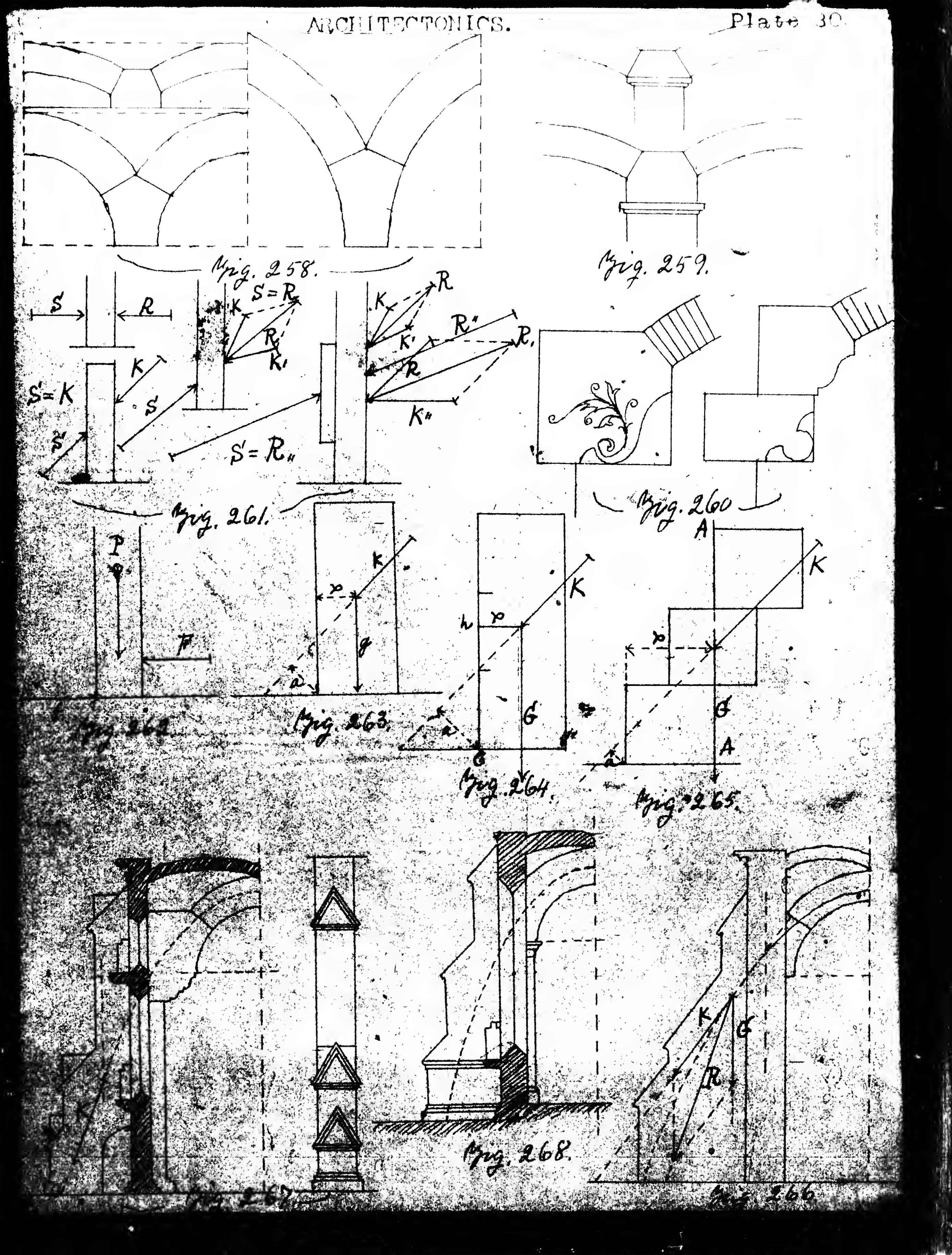


Fig. 258.

Fig. 259.

Fig. 260

Fig. 261.

Fig. 262

Fig. 263.

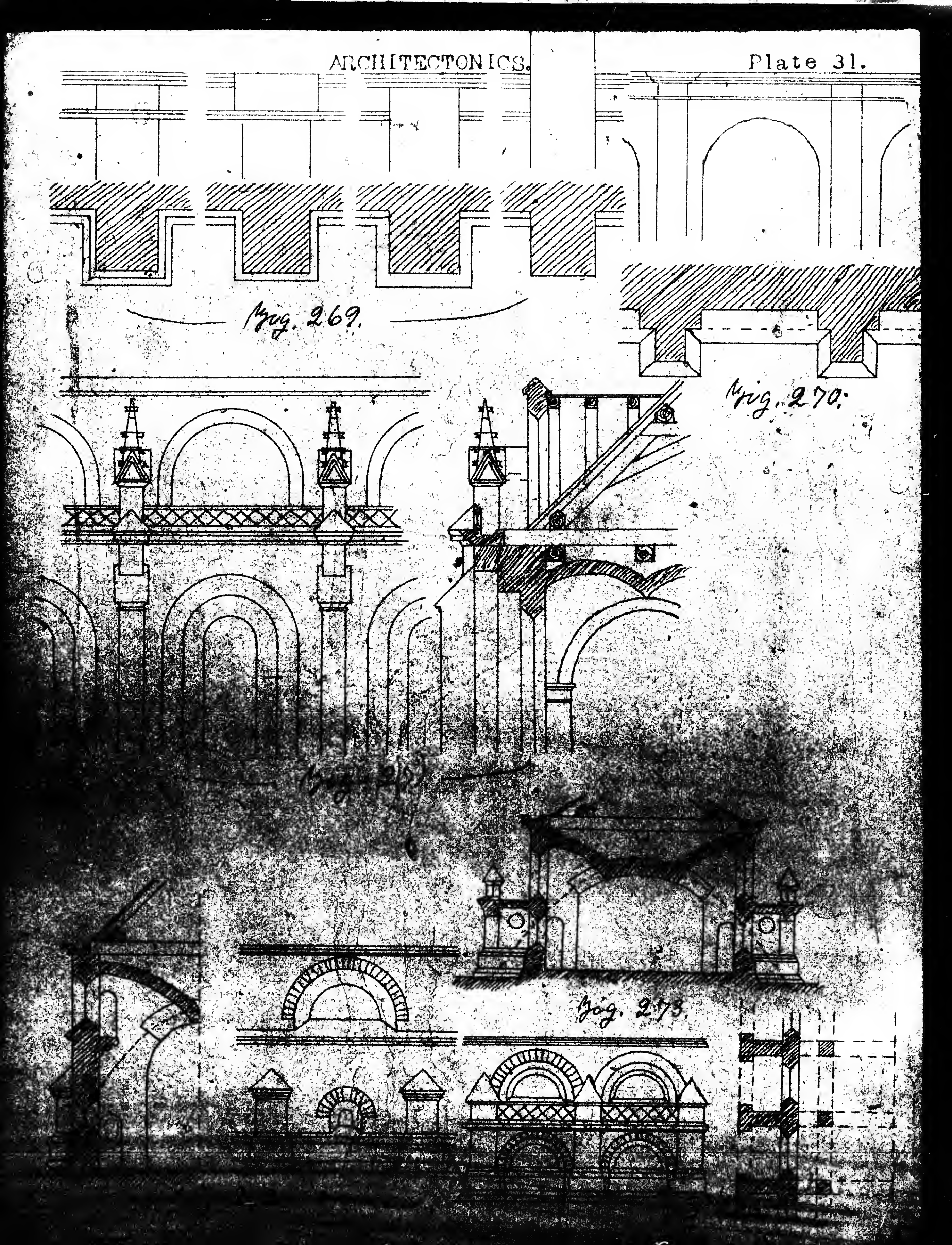
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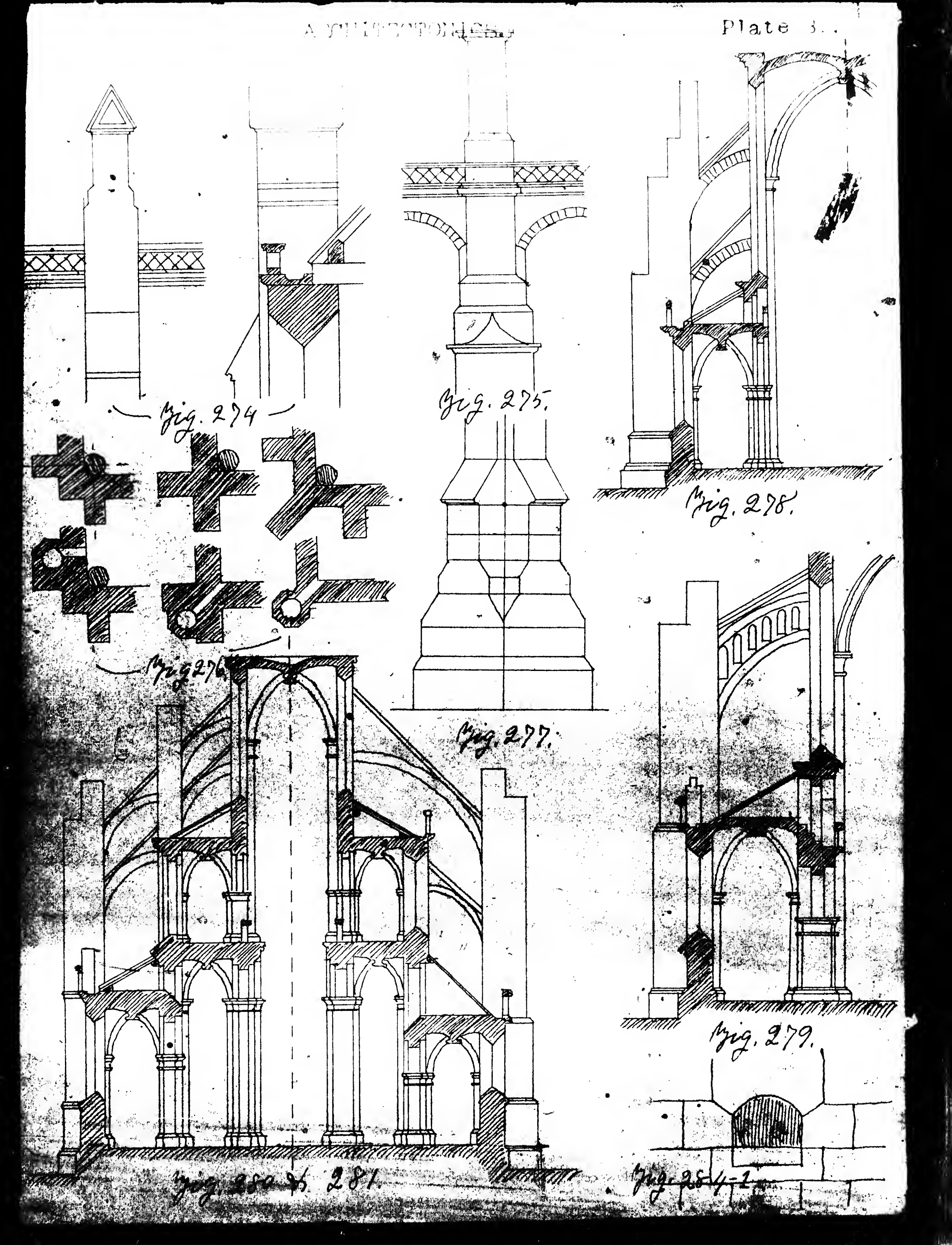
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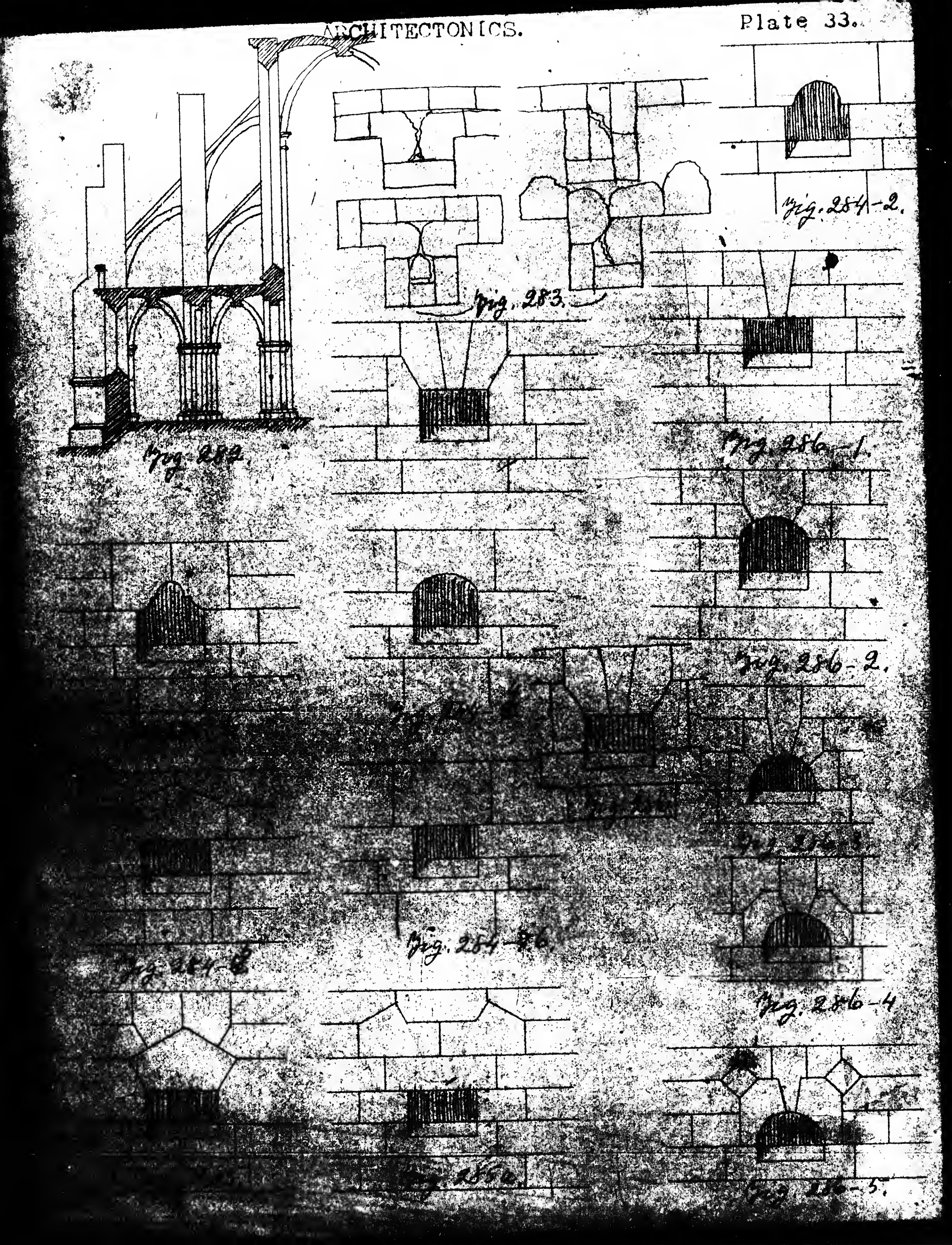
Fig. 266

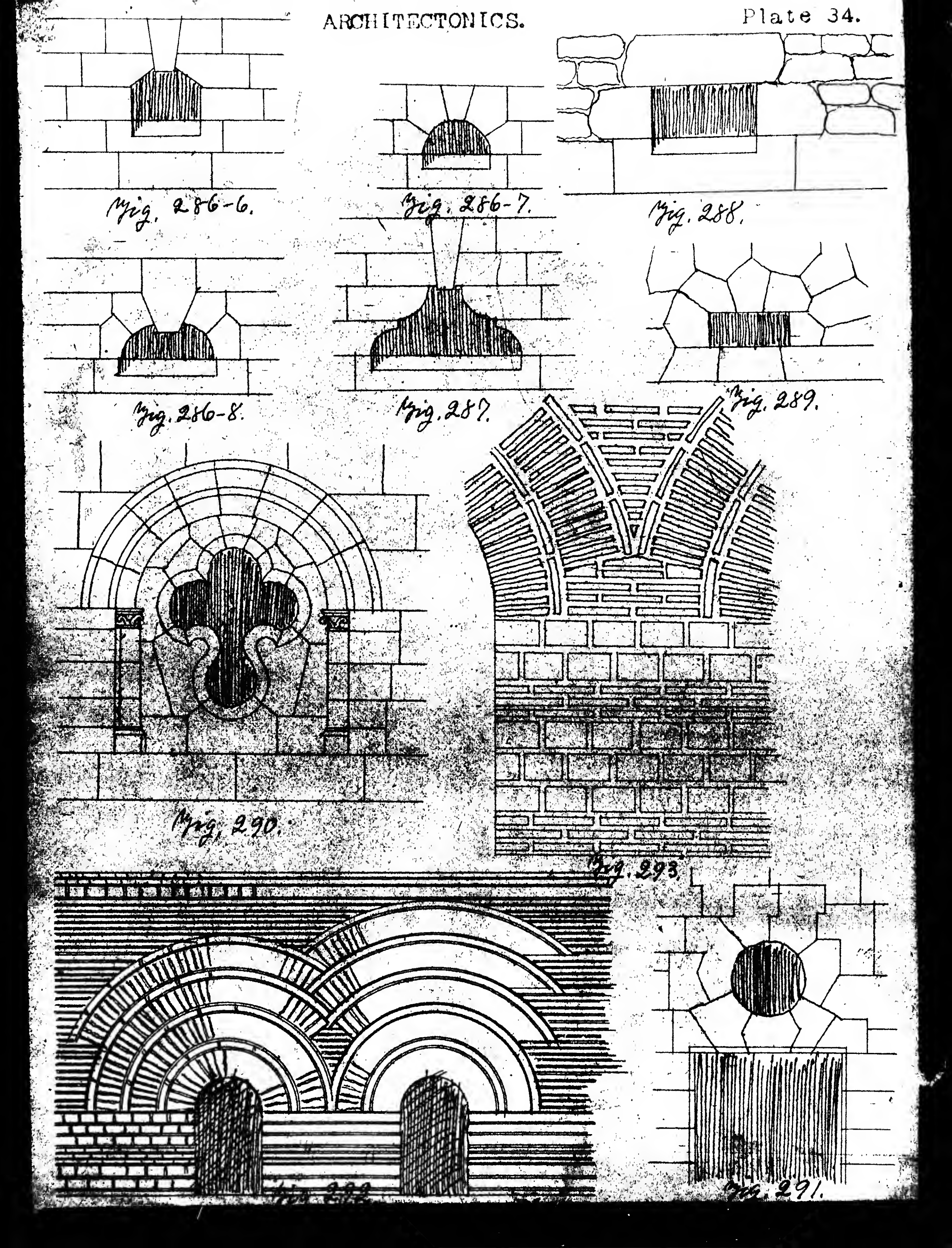
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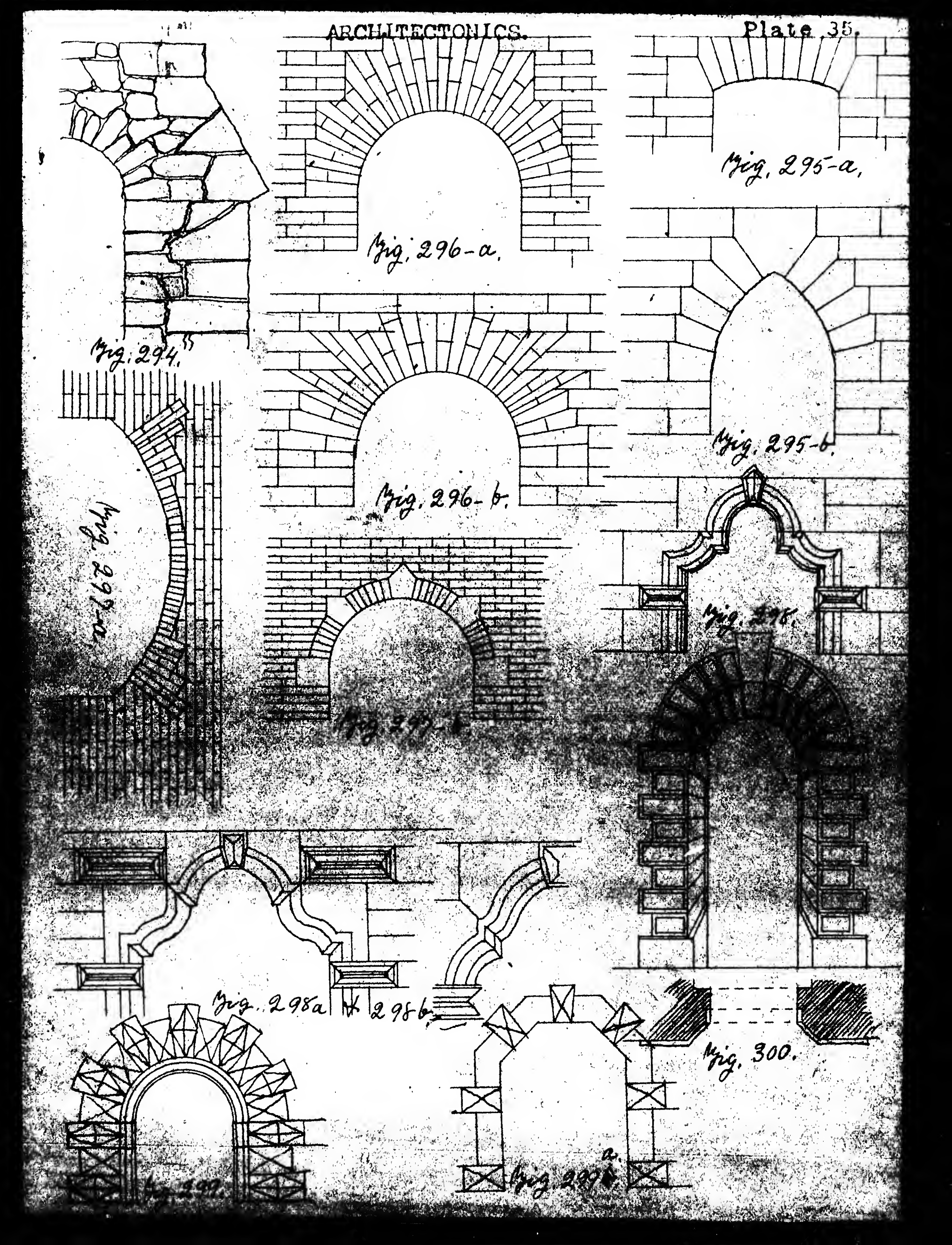
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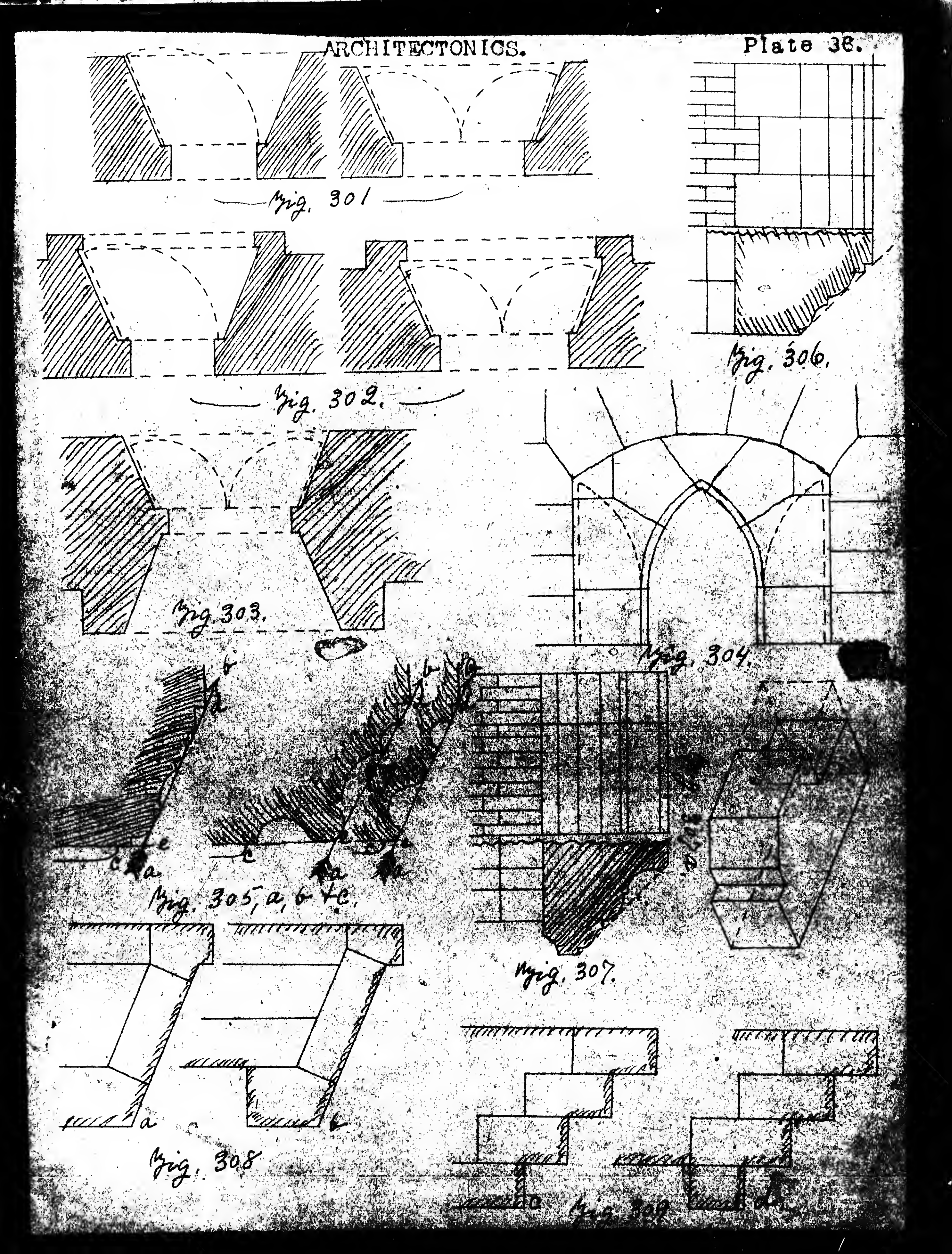

Fig. 269.
Fig. 270.
Fig. 273.

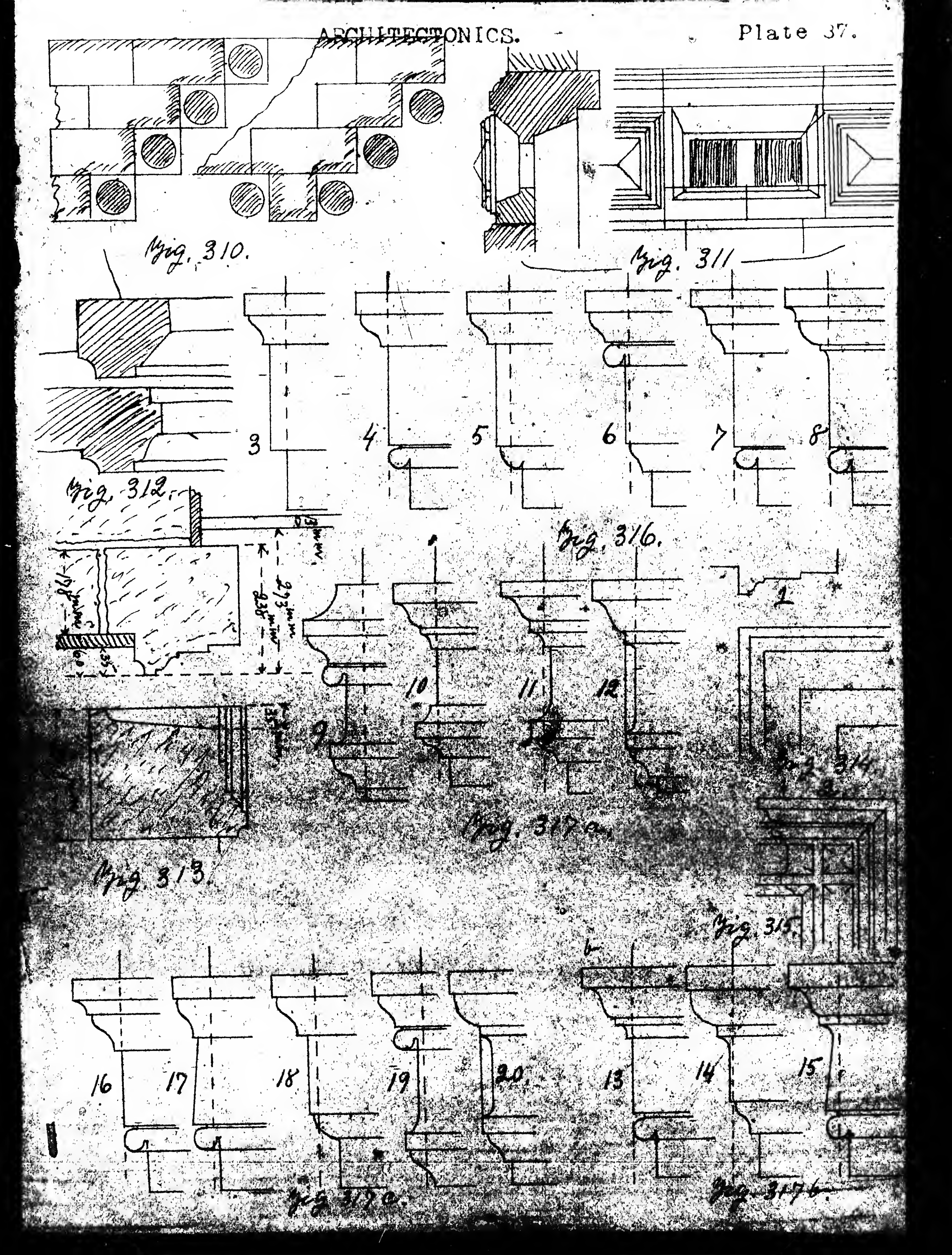

Fig. 274
Fig. 275.
Fig. 276
Fig. 277.
Fig. 278.
Fig. 279.
Fig. 280 & 281.
Fig. 284-1

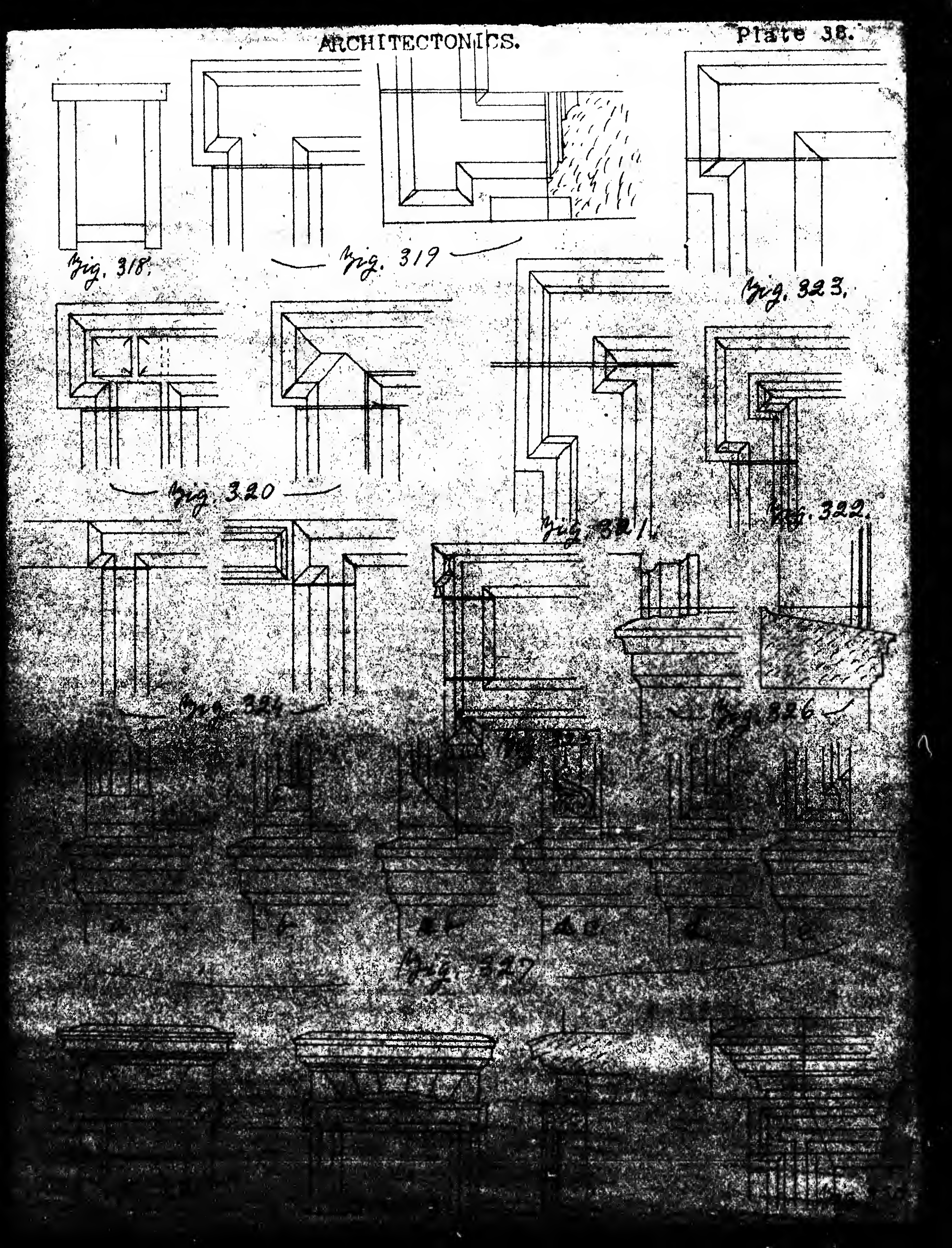

Fig. 282
Fig. 283
Fig. 284-2.
Fig. 286-1.
Fig. 286-2.
Fig. 286-4
Fig. 285a.

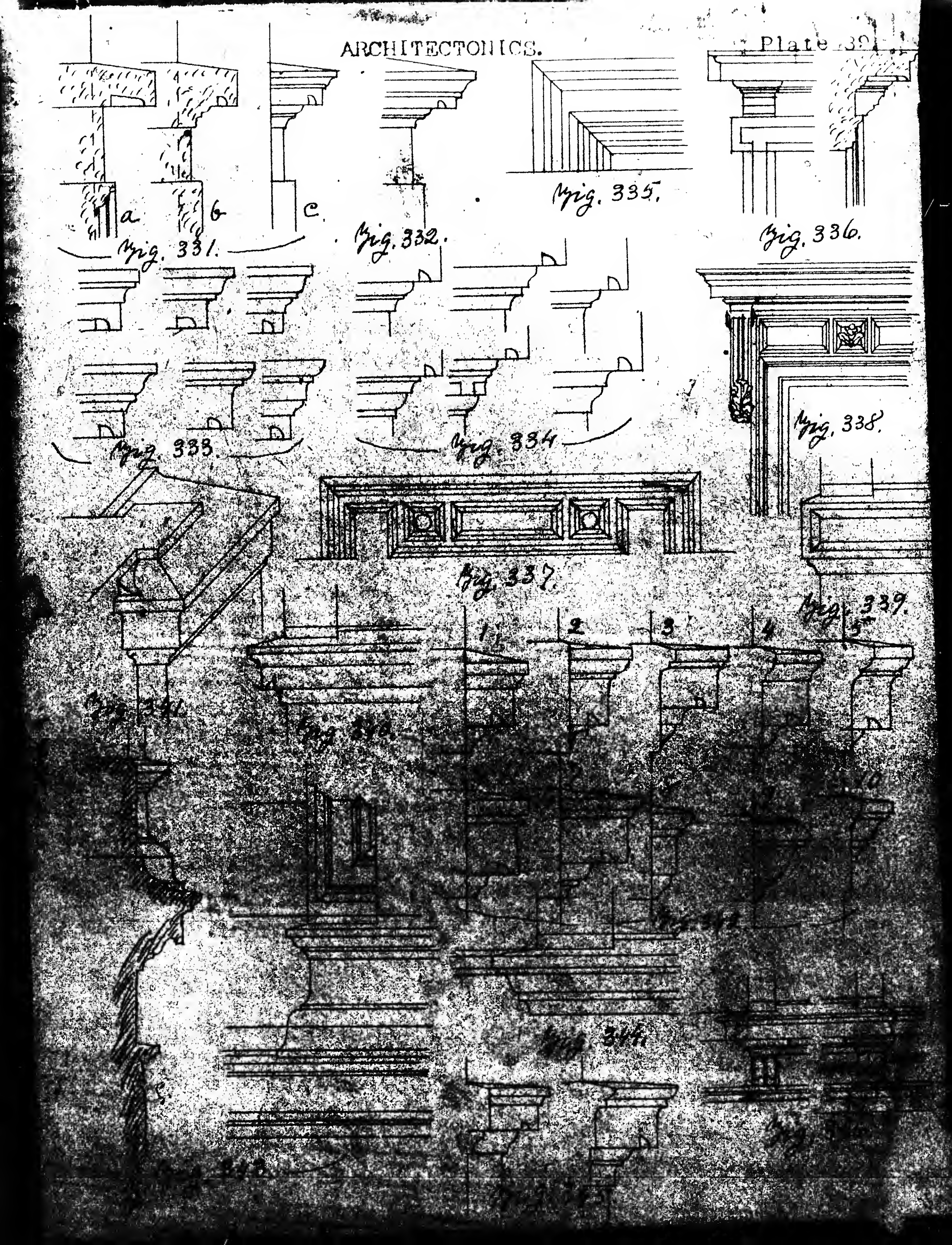

Fig. 286-6.
Fig. 286-7.
Fig. 288.
Fig. 286-8.
Fig. 287.
Fig. 289.
Fig. 290.
Fig. 293.
Fig. 291.

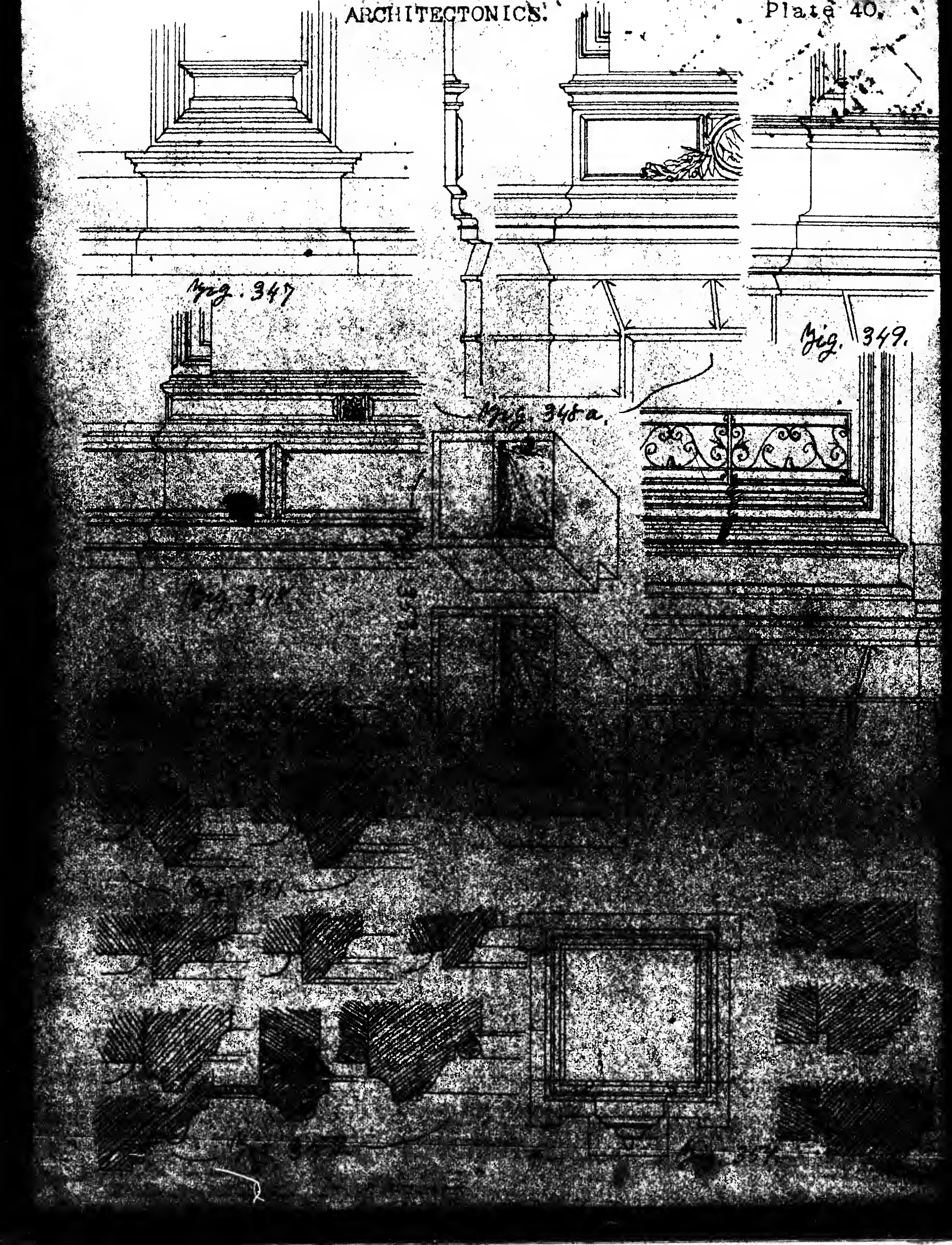

Fig. 294.
Fig. 296-a.
Fig. 295-a.
Fig. 296-b.
Fig. 295-b.
Fig. 297-a
Fig. 297-b
Fig. 298.
Fig. 298a
298b.
Fig. 300.
Fig. 299.
Fig. 299 a.

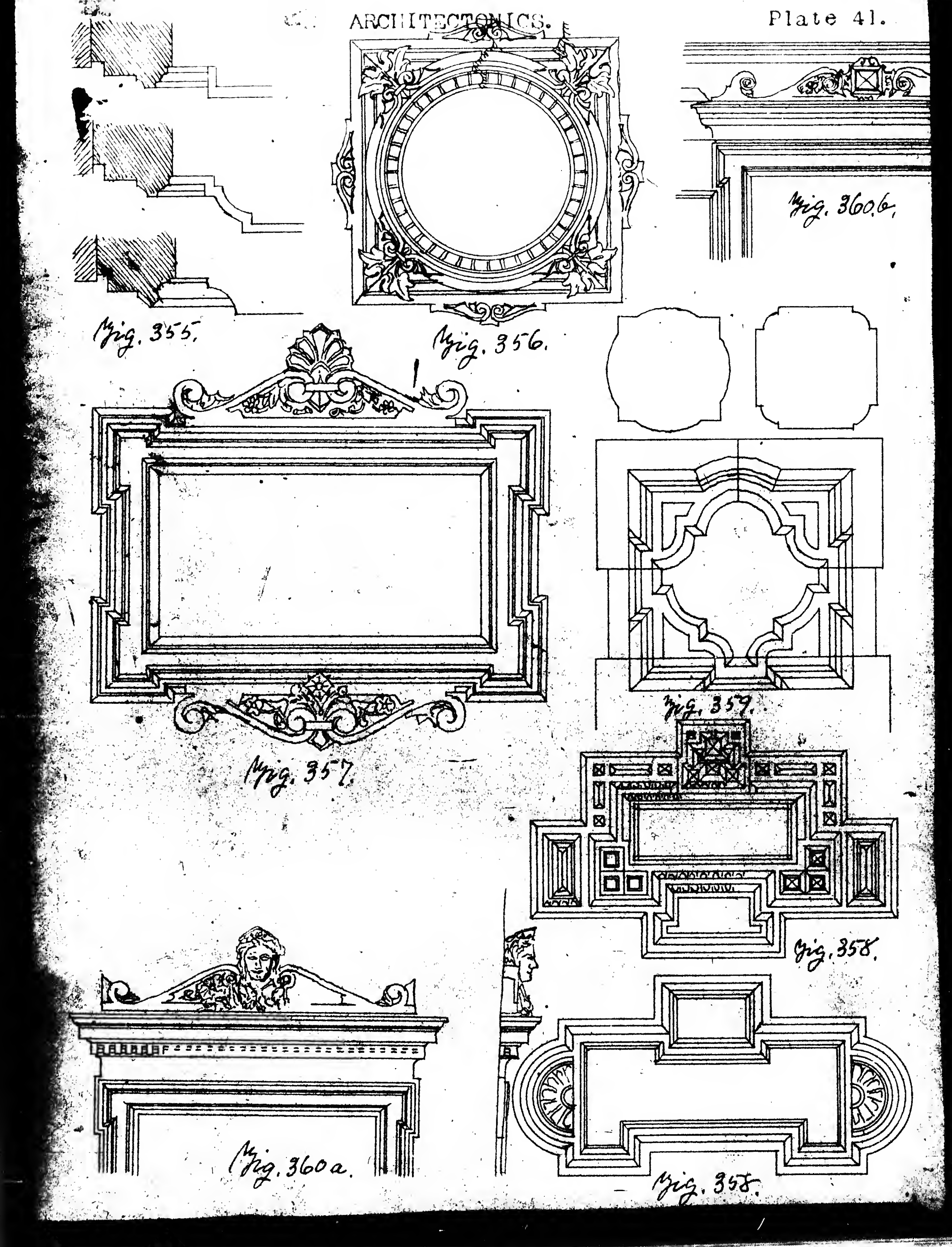

Fig. 301
Fig. 302.
Fig. 303.
Fig. 304.
Fig. 305, a, b & c.
a
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Fig. 306.
Fig. 307.
Fig. 308
a
b
Fig. 309

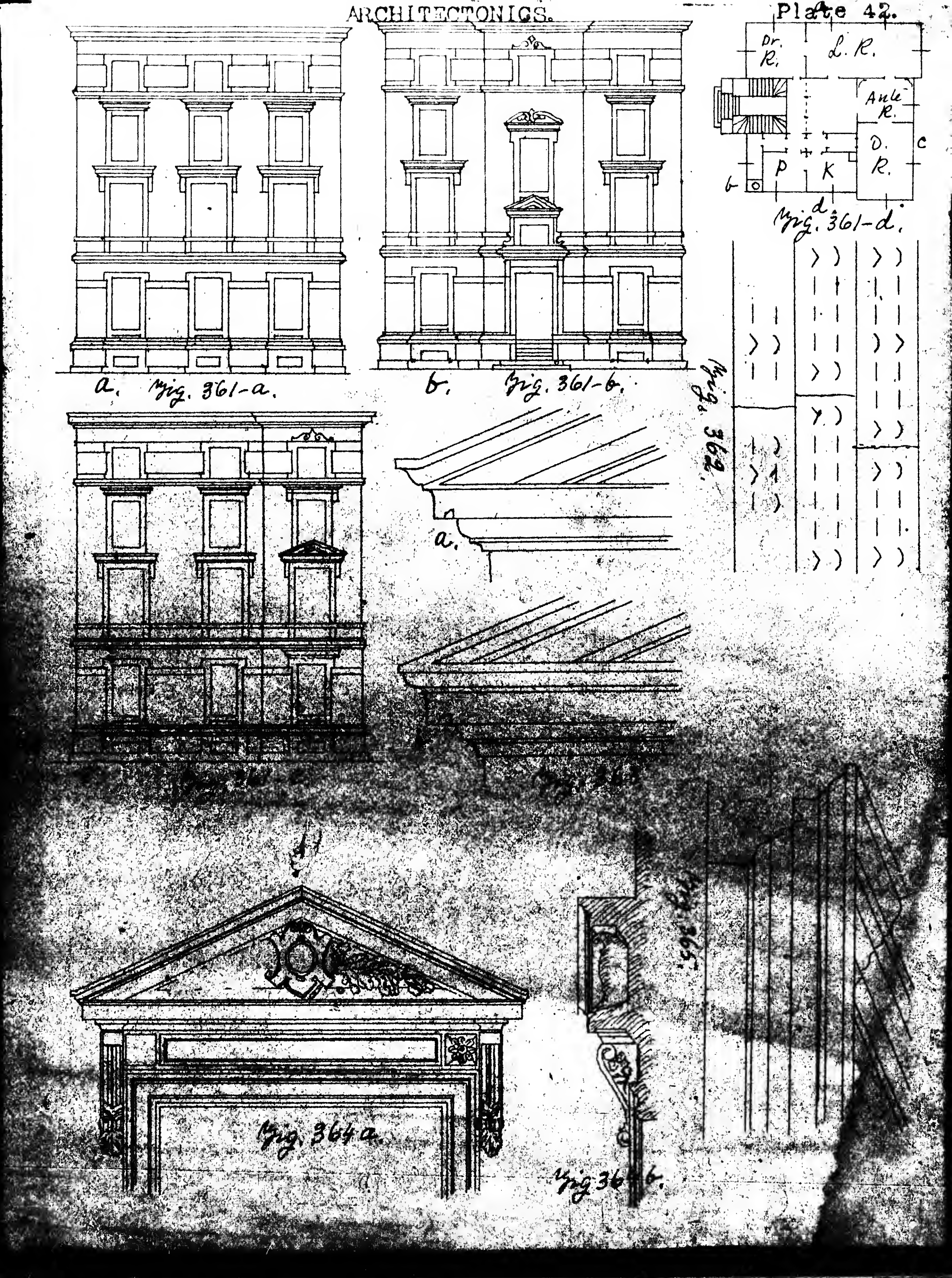

Fig. 310.
Fig. 311
Fig. 312.
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Fig. 316.
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Fig. 313.
Fig. 314
Fig. 315.
Fig. 317 a.
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Fig. 317 a.
Fig. 317 b.


Fig. 318.
Fig. 319
Fig. 320
Fig. 321
Fig. 322.
Fig. 323.
Fig. 324
Fig. 326
Fig. 327


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b
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Fig. 331.
Fig. 332.
Fig. 335.
Fig. 336.
Fig. 333
Fig. 334
Fig. 338.
Fig. 337.
Fig. 339.
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Fig. 341.
Fig. 340.
Fig. 344.


Fig. 347
Fig. 348 a.
Fig. 349.
Fig. 348.


Fig. 355.
Fig. 356.
Fig. 360 b.
Fig. 357.
Fig. 357.
Fig. 358.
Fig. 360 a.
Fig. 358.



Dr. R.
L. R.
Ante R.
D. R.
P
K
b
c
d
Fig. 361-d.
a.
Fig. 361-a.
b.
Fig. 361-b.
Fig. 362.
a.
Fig. 365.
Fig. 364 a.
Fig. 364 b.